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**CLIMATE SURVEY ANALYSIS
FOR AVIATION MAINTENANCE SAFETY**

by

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September 1998

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Naval Aviation has been challenged to cut its 1996 human factors related Class A flight mishap rate in half by the year 2000. Investigations show that human caused flight mishaps have not declined as rapidly as mechanical ones. From fiscal year 1990 through 1997, maintenance was a causal factor in 17 percent of Class A flight mishaps. Presently, there is an ongoing effort to identify factors contributing to human error in aviation maintenance. One major component is the development of an instrument to assess safety climate and posture in maintenance operations. This thesis is the climate safety assessment portion of this effort. It utilizes and adapts an existing Model of Organizational Safety Effectiveness (MOSE) to achieve an understanding of the possible influences of organizational factors on aviation maintenance. This thesis develops and administers a prototype Maintenance Climate Assessment Survey (MCAS) that provides a tool for assessing safety in maintenance operations. The study has 268 participants from three Reserve squadrons that represent the spectrum of aviation communities. The prototype MCAS is comprised of 67 questions developed from 155 candidate questions. Each question uses a Likert type rating scale, which allows participants to express opinions for each item presented. Cluster and Factor analysis is used to identify redundancies between items and how items clustered according to the MOSE components. The product of this study is a finalized MCAS with 35 questions that can be used by the Squadron command and Aviation Safety Officer to assess their unit's safety posture in conducting scheduled/unscheduled maintenance operations.

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CLIMATE SURVEY ANALYSIS FOR AVIATION MAINTENANCE SAFETY

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Naval Aviation has been challenged to cut its 1996 human factors related Class A flight mishap rate in half by the year 2000. Investigations show that human caused flight mishaps have not declined as rapidly as mechanical ones. From fiscal year 1990 through 1997, maintenance was a causal factor in 17 percent of Class A flight mishaps. Presently, there is an ongoing effort to identify factors contributing to human error in aviation maintenance. One major component is the development of an instrument to assess safety climate and posture in maintenance operations. This thesis is the climate safety assessment portion of this effort. It utilizes and adapts an existing Model of Organizational Safety Effectiveness (MOSE) to achieve an understanding of the possible influences of organizational factors on aviation maintenance. This thesis develops and administers a prototype Maintenance Climate Assessment Survey (MCAS) that provides a tool for assessing safety in maintenance operations. The study has 268 participants from three Reserve squadrons that represent the spectrum of aviation communities. The prototype MCAS is comprised of 67 questions developed from 155 candidate questions. Each question uses a Likert type rating scale, which allows participants to express opinions for each item presented. Cluster and Factor analysis is used to identify redundancies between items and how items clustered according to the MOSE components. The product of this study is a finalized MCAS with 35 questions that can be used by the Squadron command and Aviation Safety Officer to assess their unit's safety posture in conducting scheduled/unscheduled maintenance operations.

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EXECUTIVE SUMMARY

Naval Aviation has been challenged to cut its 1996 human factors related Class A flight mishap rate in half by the year 2000. Numerous engineering and programmatic intervention strategies have been put in place to reduce aviation mishaps, and subsequently, the annual flight mishap rate. Improved aircraft reliability, advanced cockpit technologies, upgrades to avionics, and new acquisitions have lead to improvements that have helped to lower the mishap rate. However, mishaps are still occurring. Investigations show that while the mechanical-caused flight mishap rate has fallen significantly to an all time low, the human-caused flight mishap rate has not declined as rapidly and has possibly increased in the last 10 years (Naval Safety Center, 1997).

On the heels of the 29 January 1996 Nashville, Tennessee, F-14 fighter jet mishap that killed the aircrew and several local residents, Vice Admiral Bennitt, Commander Naval Air Force, U.S. Pacific Fleet, created a Human Factors Quality Management Board (HFQMB) to improve aviation safety by preventing human error. The HFQMB was chartered to examine factors contributing to human error, especially aircrew error.

In 1997, the Navy and Marine Corps had an impressive year; their combined class A flight mishap rate was the second lowest ever recorded and it was the Navy's best ever recorded (NSC, 1998). Given this success, a shift to improve maintenance was initiated. Of all the identified causal factors that contributed to Class A flight mishaps from fiscal year 1990 through 1997, 17 percent involved maintenance. "Maintenance" causal factors are primarily due to human errors by maintenance personnel and/or maintenance supervisors. The maintenance thrust of the HFQMB adapted the same approach of benchmarking, mishap data analysis, and climate safety assessment. This thesis is the climate safety assessment portion of an ongoing study of Naval Aviation maintenance operations.

Organizational culture has an effect on the entire organization. This is especially true in high-risk organizations where potential outcomes of a system failure can be catastrophic and costly. Naval Aviation is recognized as a high-risk organization, which can experience devastation if something goes awry. This also holds true for aviation maintenance as well as operations. This study involves the analysis of data from a prototype survey that is based on an existing model of high-risk organizations. The purpose of this study is to develop, administer, and validate a Maintenance Climate Assessment Survey (MCAS) to assess the effectiveness of Naval Aviation maintenance operations in the management of risk. It utilizes and adapts an existing Model of Organizational Safety Effectiveness (MOSE). This study analyzes the MCAS data; the results are intended to improve our understanding of the possible influences of human factors in aviation maintenance related mishaps, and to provide a tool that can be used by the Squadron command and Aviation Safety Officer to assess their unit's safety posture in conducting scheduled / unscheduled maintenance operations.

The study includes a total of 268 participants, of whom 212 are maintainers, from three Reserve squadrons that represent a variety of Naval Aviation communities. The prototype MCAS comprised 67 questions developed from 155 candidate questions. Each question contained five point Likert scales (strongly disagree, disagree, neutral, agree, and strongly agree) which allowed participants to rate items according to their views. The questions fit into six components of the MOSE: Process Auditing, Reward System and Safety Culture, Quality, Risk Management, Command and Control, and Communication / Relationships. The data analysis entails descriptive statistics, cluster analysis and factor analysis for objective identifications of redundancies among items and how items clustered according to the MOSE components. Redundant questions are eliminated and questions with common intent are combined. Some questions remain the same. Thorough analysis of the questions produce a finalized MCAS with a total of 35 questions that can be used for individual squadron self-assessment of safety posture in scheduled / unscheduled maintenance operations.

I. INTRODUCTION

Naval Aviation is an inherently complicated system, from flying the platform into a hostile environment to landing it on an aircraft carrier. Complex systems have many forces acting on them, some synergistically, some separately, all having either positive or negative effects (Perrow, 1986). Such forces and the effects they have on the system are difficult to grasp and understand (Bond, Byran, Rigney, & Warren, 1975). These forces can lead to pilot errors, cause failures in the platform or create a range of causal factors that can lead to the loss of a platform, or worse, lives, thus having a direct effect on combat readiness. Warfighting readiness and victory in combat can be achieved by keeping the platforms functional and the pilots alive (Nutwell & Sherman, 1997).

A. BACKGROUND

The Naval Aviation Safety Program (Chief of Naval Operations Instruction 3750.6Q, 1989) was established to deal with aviation mishaps and any related causal factors. The purpose of this program is to preserve human and material resources while its objective is to eliminate hazards, the causes of damage and injury. In essence, the program was set up to determine all hazards that can become causal factors leading to aviation mishaps.

Numerous efforts have been employed in attempts to lower the Class A flight mishap rate (Figure 1). These efforts resulted in the creation of several institutions and programs, including the Naval Aviation Safety Center (now Naval Safety Center – NSC), the Naval Aviation Maintenance Program (NAMP), the Fleet Replacement Squadron (FRS) concept, the Naval Air Training & Operating Procedures & Standards (NATOPS), and the Squadron Safety Program (SSP). Additional efforts include Aircrew Coordination Training (ACT), Human Factors Councils/Boards (HFC/B), and Operational Risk Management (ORM).

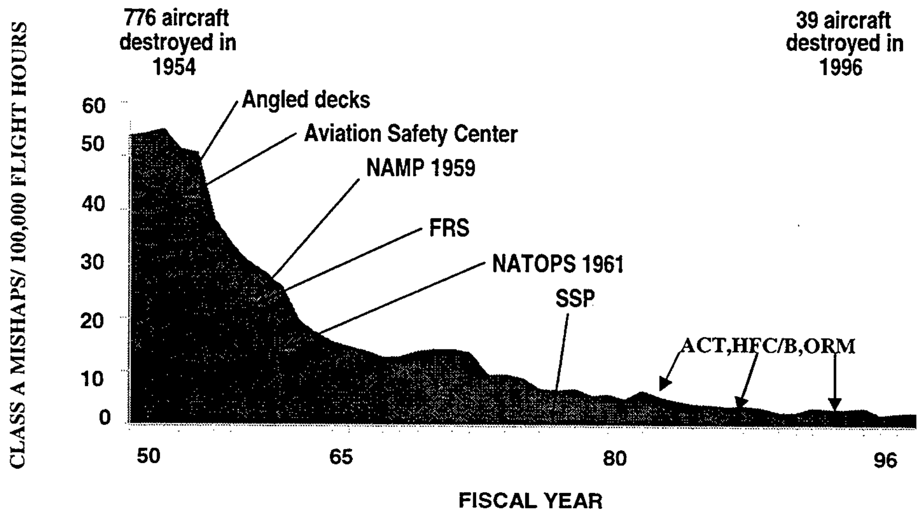

Figure 1. FY 50-96 Flight Mishap Rates and Intervention Strategies. From "Naval Safety Center Brief," by Admiral F. Dirren, April 1997.

All of the above efforts are intervention strategies put in place to reduce aviation mishaps and the annual flight mishap rate. The first five programs mentioned are design and programmatic in type. The last three break from an engineering and management focus to concentrate more on human factors issues. Improved aircraft reliability, advanced cockpit technologies, upgrades to avionics, and new acquisitions have lead to improvements that lower the mishap rate. However, mishaps are still occurring. Since 1990, approximately 4 of every 5 Department of the Navy (DON) Class A flight mishaps (those involving aircraft damage in excess of one million dollars or fatal injury) involve human factors (Department of the Navy (DON), 1997). For example, in 1997, of the 27 aircraft destroyed, 23 involved human factors.

Naval Aviation has been challenged to cut its 1996 human factor related Class A flight mishap rate in half by the year 2000. To do this, it must systematically and continuously improve all of the processes, programs, and systems affecting the safety of Naval Aviation operations (Nutwell & Sherman, 1997). The Naval Aviation Class A flight mishap rate has been significantly reduced over the past few decades. However, it appears to have reached a plateau over the past decade as indicated in Figure 2.

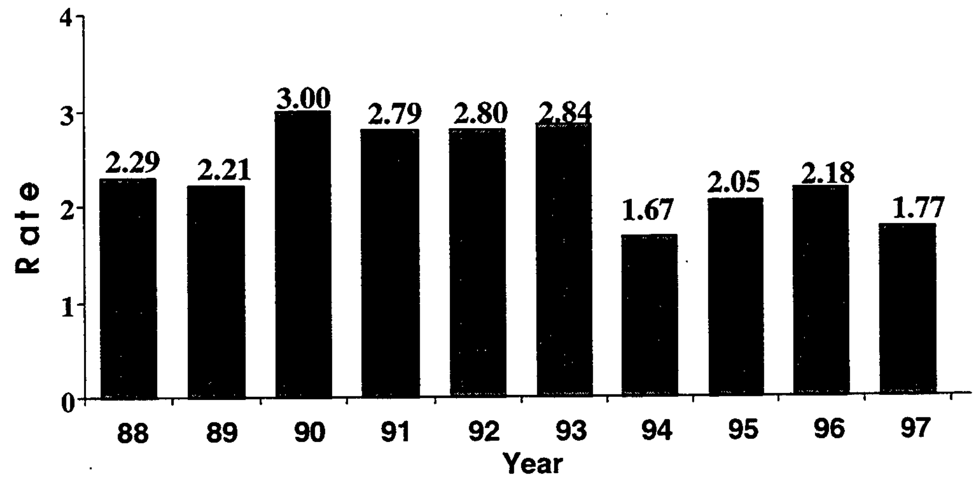

Figure 2. Naval Aviation Class A Flight Mishap Trend FY 88-97.
Rate is Defined as the Number of Class A, B, & C Flight Mishaps Per 100,000 Flight Hours.

Though the Navy and Marine Corps flight mishap rate has generally decreased over the past two decades, the rate of decline has slowed. Investigations show that while the mechanical-caused flight mishap rate has fallen significantly to an all time low, the human-caused flight mishap rate has not declined as rapidly and is possibly leveling off or even increasing in recent years (NSC, 1997). Some conclude that this split is due to the complexity of the aircraft and current pressures of operations tempo, personnel downsizing, etc (Schmidt, 1998). Figure 3 shows this relationship.

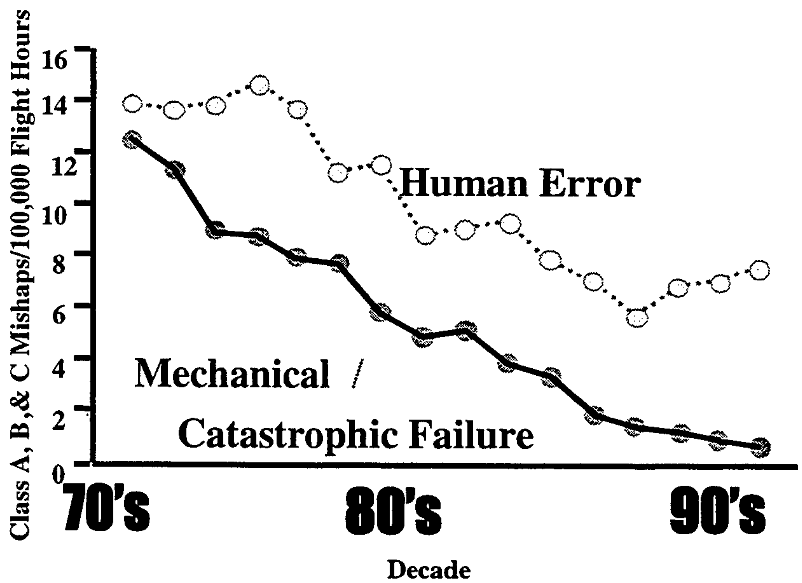

Figure 3. Mechanical/Catastrophic Failures vs Human Errors Over All Mishaps. From "Naval Safety Center Brief," by Admiral F. Dirren, April 1997.

Figure 4 shows the percentage of determined causal factors that contributed to Class A flight mishaps from FY90 – FY97. Supervisory factors were present in 62 percent of these flight mishaps. Examples of supervisory factors include inadequate command supervision of flight operations or safety, failures to correctly assess mission risks, and the inappropriate handling of a known high-risk situation. The aircrew was found to be a causal factor in 56 percent of the mishaps. Material factors, defined as material failure of the component, were present in 39 percent of the mishaps. Maintenance was found to be a causal factor in 17 percent of mishaps. This "maintenance" causal factor was primarily due to human errors by maintenance personnel or maintenance supervisors. Facilities factors, relating to human errors in conjunction with airfield operations, contributed to five percent of the mishaps.

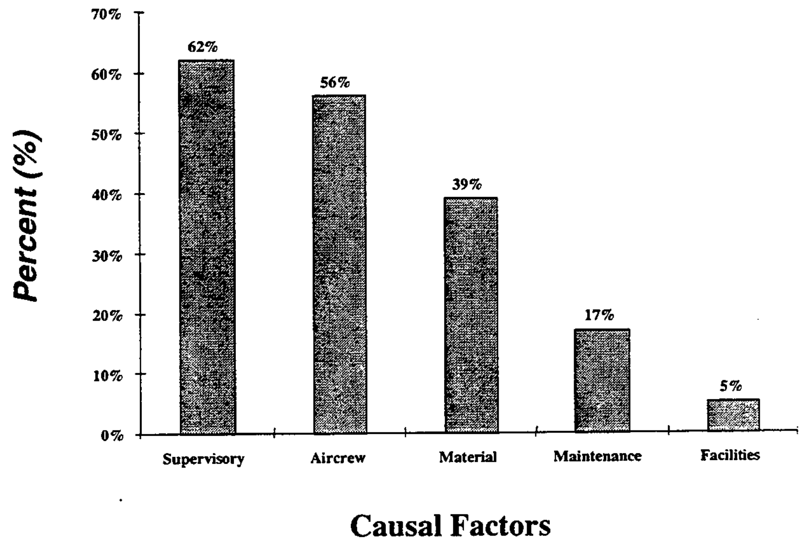

Figure 4. Navy and Marine Corps Fiscal Year 90-96 Class A Flight Mishap Causal Factors. From "Naval Safety Center Brief," by Admiral F. Dirren, April 1997.

On the heels of the 29 January 1996 Nashville, Tennessee, F-14 fighter jet mishap that killed the aircrew and several local residents, Vice Admiral Bennitt, Commander Naval Air Force, U.S. Pacific Fleet, created a Human Factors Quality Management Board (HFQMB) to improve aviation safety by preventing human error. The charter of the HFQMB is to analyze and improve each of the processes, programs, and systems that impact human performance in aviation with the purpose of dramatically reducing the annual flight mishap rate (DON, 1997). In other words, its main objective is to analyze human factors involvement in past Naval Aviation mishaps and in present Naval Aviation operations. Preventing a mishap contributes to readiness and mission success by keeping people and airplanes available through controlling safety-related hazards. Most of the HFQMB initiatives directly contribute to mission readiness, as well as indirectly, through mishap prevention (Nutwell & Sherman, 1997).

Three processes define the HFQMB methodology: Benchmarking, Mishap Data-Analysis (MDA), and Command Safety Assessment (CSA). These lead to brainstorming and potential intervention strategies, which in turn result in recommendations presented to the Navy's Air Board of Flag officers (Figure 5). Benchmarking occurred with visits to commercial airlines, private industry, sister services, NASA, the FAA, NATO partners, and academia. The objective was to examine the culture, training, safety, and leadership of each organization; to identify and learn about successful safety practices in order to adopt best practices, identify lessons learned, and avoid "re-inventing the wheel."

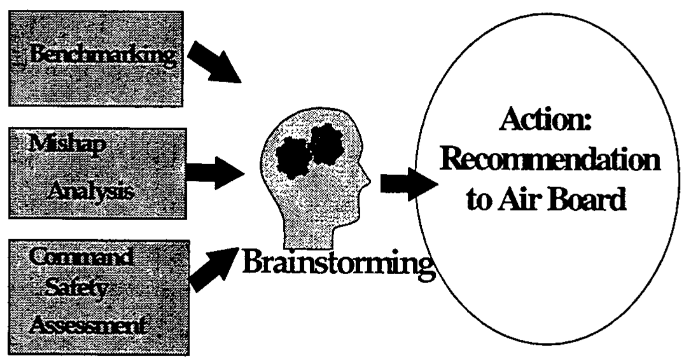

Figure 5. HFQMB Methodology.
From "AIRPAC Brief," by CDR J. Schmidt, March 1998.

The MDA categorizes the human error elements of a mishap into three groups: unsafe supervisory conditions, unsafe aircrew conditions, and unsafe aircrew acts. The first two are seen as latent conditions and the last as active failures. Unsafe supervisory conditions include planned inappropriate operations, failure to correct known problems, supervisory violations, and inadequate supervision. Unsafe aircrew conditions pertain to aeromedical, personnel readiness and cockpit resource management (CRM) problems. Unsafe aircrew acts pertain to slips, lapses, mistakes, routine violations, and exceptional acts of the aircrew. Class A flight mishap data analysis from fiscal year 1990 through

1996 showed the following. Supervisory failure is a causal factor in 62 percent of Class A flight mishaps during fiscal year 1990 through 1996. Fifty one percent of the supervisory failures are labeled as unsafe supervisory conditions. The unsafe aircrew events contained: 28 percent of the flight mishaps as aeromedical, 48 percent as CRM and three percent as readiness. The unsafe aircrew act event contained 87 percent as accidental and 40 percent as violations. (Nutwell & Sherman, 1997). Notably, in a report issued in 1997 by the DON, forty percent of the volations were conscious aircrew breeches of procedures, Standard Operating Procedures (SOP) and NATOPS.

Ciavarelli's and Figlock's (1997) CSA study was conducted to assess a command's safety climate from an aircrew perspective and the perceived effectiveness of its safety related programs. Its objective was to analyze the effectiveness of managing risks in flight operations. The study, based on a model of high reliability organizations, shows significant room for improvement in risk management, human factors evaluation, and aircrew coordination training. The study's survey develops a tool that provides commanding officers and aviation safety officers (ASO) a capability for self assessment of the effectiveness of their commands safe operations (Nutwell & Sherman, 1997).

The HFQMB formed ten Process Action Teams (PAT) for areas that require intervention: Leadership, Policy, Organizational Effectiveness, Safety Information Management, Training and Qualifications, Standard Operating Procedures, Mishap Investigations, Operational Risk Management, Human Factors Evaluation and Aircraft/Aircrew Systems. The PAT were tasked to assess each area using the information taken from benchmarking, the MDA, and CSA, to identify area improvements, and recommend actions resulting in an awareness of human factors, causal factors of mishaps and, ultimately, to achieve a mishap rate reduction.

To date, there has been little emphasis on the potential contribution of human factors on maintenance operations. The HFQMB's first thrust was aimed at supervisory (62 percent) and aircrew (56 percent) causal factors due to the large percentage of mishaps involved, whereas discussed earlier, maintenance was found in 17 percent of the mishaps. In 1997, the Navy and Marine Corps had an impressive year; its class A flight mishap rate was the second lowest ever recorded and it was the Navy's best ever recorded (NSC, 1998). Success in the intervention of these two areas has led to interest in developing efforts directed at the maintenance causal factors.

The same three-pronged approach was adopted by the HFQMB for taking an in-depth look into Naval Aviation maintenance operations for the identification of hazards and the development of intervention possibilities (Figure 5) (Schmidt, 1998). Benchmarking is currently underway and mishap data analysis is now completed. The benchmarking efforts have determined that risk management contributes to enhanced safety in terms of maintenance error prevention, lower mishaps, and reduced personal injuries. Organizational culture and climate, facilitation of crew coordination and team performance, effective training and certificate programs, and emphasis on policy and procedure adherence are all areas where risk management contributes to enhanced safety. These findings reflect some of the problem areas found in an analysis of Class A flight mishaps that involved maintenance depicted issues related to supervisory, crew coordination, training/qualifications, and adherence to policy and procedures. The results from benchmarking and mishap data analysis in conjunction with the previous

CSA questionnaire were used to develop a candidate list of questions for a maintenance questionnaire.

B. PURPOSE

The purpose of this study is to develop, administer, and validate a questionnaire survey to assess the effectiveness of Naval Aviation maintenance operations in the management of risk. This study analyzes survey data and builds on a Model of Organizational Safety Effectiveness (MOSE) developed by Dr. Ciavarelli and LtCol Figlock (1996) of the School of Aviation Safety, Naval Postgraduate School, Monterey, CA. The results will improve our understanding of the possible influences of human factors in aviation maintenance related mishaps, and will provide a tool for assessing safety in maintenance operations. The intent is to identify potential interventions in an effort to lower human error in maintenance-related mishaps and the overall mishap rate.

C. PROBLEM STATEMENT

Given the sustained presence of human error in aviation maintenance, it is essential to develop a valid Maintenance Climate Assessment Survey targeting the maintainer's perspective on safety and flight practices. Given this need, the existing CSA questionnaire based on the present MOSE must be adapted to address maintenance issues. It entails possible expansion and necessary modification of the existing questionnaire, which is geared towards aircrew, and the development of maintenance specific items. This thesis explores the following questions:

1. Can the present MOSE be adapted to capture the maintainer's perspective?
2. Do the close-ended questions (questions with fixed responses) in the MCAS conform to the existing MOSE components?

3. Can the prototype MCAS be reduced through either the elimination of redundant questions or combination of such questions?

4. Are there discernable differences between squadrons surveyed, and does there appear to be any consensus?

5. Does the maintenance data support the components / structure of the maintenance adapted MOSE?

D. SCOPE AND LIMITATIONS

The intent of this study is to gain a better understanding of the Naval Aviation maintenance safety climate, understanding that efforts are underway to look into the supervisory and aircrew factors. Three California based Reserve Squadrons are used as subjects in the survey due to their availability, accessibility, close proximity; this effort is a preliminary study. Neither Marine Corps units nor active duty personnel participated in this study, nor did any Tactical Air Squadrons. Only the Naval Aviation maintenance personnel responses are used in this analysis. Incomplete surveys are omitted.

II. LITERATURE REVIEW

A. BACKGROUND

It has been evident for most of recorded history that people are prone to commit errors- "To err is human." As our technology expands, as our wars multiply, and as we invade more and more of nature, we create systems - organizations, and the organization of organizations - that increase the risk for the operators, passengers, innocent bystanders, and for future generations. Most of these risky enterprises have catastrophic potential, the ability to take the lives of hundreds of people in one blow, or to shorten or cripple the lives of thousands or millions more (Perrow, 1984). Catastrophic errors in a system are often the result of the gradual aggregation of small errors across a system. Considering organizations as systems, and as parts of systems, is important in order to understand how organizations work, and how to best mitigate risk in them (Grabowski & Roberts, 1996). Advances in technology have increased the reliability of most system components, but the percentage of human error-related incidents and accidents has remained fairly constant.

B. STUDY FRAMEWORK

The theoretical framework for the construction of the maintenance questionnaire survey used in this study is derived from the work done by Ciavarelli and Figlock (1997) at the School of Aviation Safety, Naval Postgraduate School, Monterey, CA. The framework is based on key attributes of successful organizational risk management processes identified by Libuser (1994) and Roberts (1990), and from a safety climate analysis published by Zohar (1980). The existing CSA questionnaire was generated using academic resources and professional questionnaires, which provided guidance regarding design and construction of questionnaires (Ciavarelli and Figlock, 1997).

Five major areas concerning the effectiveness of organizations at managing risk are identified in a model developed by Libuser (1994). These areas included process auditing, a reward system, quality of operations, risk perception and command and control. Libuser's work was adapted by Ciavarelli and Figlock (1997) to develop a Model of Safety Effectiveness (MOSE) that incorporates standard Naval aviation language and safety practices. The five MOSE components are summarized as follows:

1. Process Auditing – a system of ongoing checks to identify a hazardous condition and a process to take corrective actions.

2. Reward System – a system to recognize and reward safe behaviors, and to discourage unsafe behaviors.

3. Quality standards – Sets control procedures to monitor quality and correct deviations to referenced standards.

4. Risk Management – Systematic process to identify and manage risk.

5. Command and Control – Established policies and procedures to conduct safe operations.

A complete description of the MOSE components is provided in Appendix A.

Ciavarelli and Figlock's (1997) short term goal is to provide the QMB with feedback on issues concerning aviation command climate, morale of Naval Aviation personnel, squadron workload and resource availability, the estimated success of ongoing safety interventions, and other factors related to safely managing Naval flight operations. Their long-term goal is to develop, validate and apply methods for assessing and mitigating risk in organizations that must, by the nature of their business, conduct hazardous operations. They develop and apply questionnaire survey methodology to assess the effectiveness of Naval Aviation units in the management of risks associated with flight operations. This study is the first of several planned investigations intended to improve the understanding about possible influences of organizational factors in aircraft accidents, specifically understanding what possible influences a Naval Aviation command may have on the chain of events leading to an aircraft mishap (Ciavarelli & Figlock, 1997).

C. ORGANIZATIONAL CULTURE AND CLIMATE

Roberts (1990) examines organizations that are successful in managing risks associated with hazardous operations. She labels this type of an organization as a "high-reliability" organization (HRO), which operates in hazardous environments yet produces a very low rate of accidents and incidents. Grabowski and Roberts (1996) contend that strong cultures and norms that reinforce their mission and goals characterize HROs. A culture is defined as the shared values, beliefs and assumptions that may govern decision making, attitudes, safety, and proper conduct within an organization. Norms are rules and regulations that guide and control the behavior of individuals and organizations. They focus attention on procedures, policies, and reward structures that are consistent with the organization's mission. Grabowski and Roberts (1996) find that various cultures operating in large-scale systems are the glues tying the segments together.

Zohar (1980) finds strong evidence that organizations with successful safety programs have a strong management commitment to safety. She determines that in low accident companies, top management is personally involved in safety activities on a routine basis, and safety matters are given high priority in company meetings and in production scheduling. This underlying safety climate refers to the shared perception of an organization's members that the organization's leaders are genuinely committed to safety of operations. She contends that such a climate results in increased performance reliability of workers, good housekeeping, and high design and maintenance standards for work environments.

D. HRO: CLIMATE AND CULTURE

To operate a complex system successfully, the human-machine system must be supported by an organizational infrastructure of operating concepts, rules, guidelines, and documents. In high-risk endeavors such as aircraft operations, it is essential that such support be flawless, as the price of deviations can be high. When operating rules are not adhered to, or the rules are inadequate for the task at hand, not only will the system's goals be thwarted, but there may also be tragic human and material consequences (Degani & Wiener, 1994). Both Roberts (1990) and Libuser (1994) believe that organizations operating safely and effectively have certain key characteristics in common. Leadership style, sound safety management policies, procedure standardization, adequacy of resources and staffing, and a defined system for risk management are such characteristics. In large-scale systems, maintaining or developing a culture of safety and reliability can be important in mitigating risk. Oversight, checks and balances, and strong cultural norms are organizational protections and buffers that reinforce an organization's goals; they can mitigate risk by assuring errors are caught, that appropriate organizational norms are developed and reinforced, and that the system improves over time (Grabowski & Roberts, 1996).

E. AVIATION MAINTENANCE AND RAMP ACTIVITIES

As anyone working in aviation maintenance knows, there have been a number of serious, even fatal, accidents over the years that were caused primarily by maintenance errors (Reason & Maddox, 1998). Boiled down to its essence, the task of a maintenance mechanic is to take off and then replace some of the three to four million removable parts on a modern aircraft platform. Much goes on in between, of course, but these basic steps of disassembly and re-assembly remain constant features of the work — the latter attracts by far the largest number of errors (Reason, 1990). The maintenance area is an unstable environment in a number of different ways: from the point of view of human factors it does not compromise a well-designed work environment. Problems range from complex activity and congestion in a poorly delineated environment to the problems of controlling the movement of large objects in space with inadequate information and cues (McDonald & Fuller, 1994). It is clear that problems with human factors still exist in aircraft maintenance facilities – even those that are built in strict accordance with the prevailing architectural standards (Maddox, 1998). Therefore, within maintenance activities, the human operator's role is critical to safe and efficient operations.

The technology of the ground handling process also poses interesting problems for safety. Aircraft are designed to fly; they are not optimally designed for ramp operations. The aircraft's size and location in space relative to the operator invite misperceptions and misjudgments of distance and location; the fragile skin and appendages of an aircraft are easily damaged and such damage if undetected, can have disastrous consequences in flight. The cyclical nature of the ramp operator's job often requires immediate and demanding increases of both mental and physical performance from a resting and perhaps fatigued level (McDonald & Fuller, 1994).

There are many factors within a maintenance and ramp activity that can be associated with failures (Reason & Maddox, 1998). These factors can have an adverse effect upon the working practices of those within the maintenance and ramp areas and hence, human performance. Factors within the workplace are known as local errors, and those that lie within the organization, organizational factors. The organizational factors create the local errors.

One such local factor is the knowledge, skills and experience of maintenance personnel; personnel can be unfamiliar with a defect or aircraft type, lack specific training or skills and have inappropriate experience to perform proper maintenance. A morale factor can exist; people clash in personality, get frustrated, or can be unhappy with the work situation. Availability of tools, equipment and parts quality may be another factor. Other local factors may include fatigue, the pressures of a high workload, problems with shift patterns, and environmental problems. Unclear manuals and procedures, quality of safety equipment and training may also be present (Maddox, M, 1998).

An organizational factor may be organization structures; there can be concerns about restructuring and downsizing, ill-defined duties, or too many layers of management in the organization. People management, the lack of top level awareness of problems that technicians face, and ill-defined career paths, may be an issue. Training, operational pressures, planning and scheduling problems and communication within the organization can also be examples of organizational factors. These factors are usually present within most maintenance facilities, and can directly impact the climate within which the maintenance technician or ground handler must cope. The maintenance and ramp activity is a dangerous work environment presenting the risk of death or disabling injury to those involved. There is an ever-present potential for unreported ground handling damage to aircraft while in the hangar or on the ramp. Therefore, policies and procedures are needed to minimize this potential (Maddox, 1998).

F. PHILSOPHY, POLICY, PROCEDURES AND PRACTICES

Philosophy, policy, procedures and practices, the four P's, are recognized as important aspects in flight deck operations (Degani & Wiener, 1994). Philosophy deals with the over-arching view of how the organization will conduct business, including flight operations. An organization's philosophy is largely influenced by the organization's leaders, and also by its culture. Policies are broad specifications of the manner in which management expects operations such as training, flying, and maintenance to be performed. An organization's policy embodies the philosophy.

Procedures should be designed to be as consistent as possible with the policies, which are consistent with the philosophy. Procedures exist to specify what the task is, when the task is conducted and by whom, how the task is done, and the sequence of actions needed to perform the task. Practices are an extension of and are governed by the philosophy, policies and procedures within an organization. A practice is the activity actually conducted on the flight deck and it is the ultimate factor that determines the quality of a systems output. The goal of management is to promote 'good' practices by specifying coherent procedures (Degani & Wiener, 1994). Maintenance, like flight deck operations, is an activity that relies heavily on the four P's described above; there is the leadership philosophy, the policies within the maintenance department, the Standard Operating Procedures (SOP), and the technician's or mechanics practices.

G. ASSESSMENT AND INTERVENTION OF RISK

Looking at all the components within the MOSE and seeing if these apply to the Naval Aviation maintenance community is called its assessment. Do the five components of process auditing, reward system and safety culture, quality, risk management, and command and control relate to maintenance? Assessing maintenance operations shows that indeed, these components are present. There is a need for the auditing of maintenance logs and SOP. A strong safety culture is a must; everyone must be safety conscious and identify safety problems. Quality control is the heart of maintenance, maintenance is definitely a high-risk environment, and leadership must be present to ensure the commitment to safety.

Intervention is the gathering of data from a process, the attempts to fit a model to the data, and learning more about the process. A better understanding of the organizational factors related to safely managing maintenance operations is needed and desired. A survey of the maintenance community, based on the MOSE adapted for maintenance, is one method of intervention. Surveys are most appropriate when information should come directly from people involved with the process. Surveys provide data describing attitudes, values, habits, and background characteristics such as age, education and income (Fink & Kosecoff, 1985). Ciavarelli and Figlock's (1997) MOSE can be adopted to incorporate maintenance terms and language, thus developing a needed tool for intervention.

H. SUMMARY

Organizational culture has an effect on the entire organization. This is especially true in high-risk organizations where potential outcomes of a system failure can be catastrophic and costly. Naval Aviation is recognized as a high-risk organization, which can experience devastation if something goes awry. This is also true in the aviation maintenance community. Several approaches have been made to improve the overall safety of Naval Aviation: a system safety analysis, an analysis of mishap data and surveys to improve the understanding of organizational issues pertaining to operators. If the concepts of systems safety and organizational accidents are to be advanced, aviation management at all levels must be aware of them (Reason, 1990). There is a need to develop a survey to gain a better understanding of the organizational influences on maintenance error. In looking at different survey methods, a self-administered survey needs to be developed for the Naval Aviation maintenance community.

III. METHODOLOGY

A. RESEARCH APPROACH

The intent of this study is to develop a Maintenance Climate Assessment Survey (MCAS) for the Naval Aviation Maintenance community that captures the maintainer's perception and understanding of the risks within their department and in performing their mission. This study involves the analysis of data from a prototype survey that is based on an existing model of high-risk organizations. This is done to identify factors that may improve safety within aviation maintenance. The data analysis entails descriptive statistics, cluster analysis and factor analysis.

B. DATA COLLECTION

1. Subjects

A total of three Naval Air Reserve Force squadrons, two located at NAS North Island and one at Moffett FAF, are surveyed. The first is a Fixed Wing Fleet Logistics Support (VR) Squadron composed of active duty and selected reserve personnel providing seven-day-a-week round the clock, worldwide logistics to support the Navy and Marine Regular and Reserve forces. The second consists of a Fixed Wing Maritime Patrol (VP) Squadron with a worldwide theater of operations, composed of Selected Reservists and active duty personnel (Note: This squadron is decommissioning). The third squadron consists of a Rotary Wing Combat Support (HCS) Squadron with a mission of Search and Rescue, Combat Support via the launch and recovery of targets and torpedoes on the Southern California Offshore Range (SCORE).

The survey respondents are primarily Navy enlisted personnel who work in aviation maintenance departments. Maintenance personnel from the VR Squadron located at the Naval Air Station (NAS) North Island, CA were used to test the reliability and consistency of the prototype survey. The survey was then administered to two other groups of maintenance personnel from the VP and HCS Squadrons.

2. Instrument

The prototype MCAS consists of 15 demographic and 67 maintenance related questions. Demographic questions included inquiries about rank, community, shift worked, total years of service, and total years of aviation maintenance experience. They also include inquiries about unit home location, rating, age and current maintenance qualifications. The demographic questions preserve anonymity of particpants; names, social security numbers, work section, etc are not asked for. The MCAS is constructed using an existing air operations oriented Command Safety Assessment survey (CSAS) as a basis.

Questions from the CSAS are re-worded to relate to "Maintainers" with maintenance terms. A focus group discussed all 156 candidate questions to reduce redundancy and ensure proper phrasing (Appendix B lists the candidate questions). Survey questions are fitted to the existing components as outlined in the current MOSE and new areas are created to fit any remaining questions. The MOSE components consist of Process Auditing, Reward Systems and Safety Culture, Quality, Risk Management, and Command & Control. Additional questions, proposed by current maintenance experts, are also incorporated into the MCAS. All questions are partitioned according to the

MOSE components, and the residual questions are examined. They fit under a sixth category peculiar to maintenance vice air operations: Communication / Relationships.

The MCAS questions are separated into the MOSE components of Process Auditing, Reward System and Safety Culture, Quality, Risk Management, Command and Control, and Communication / Relationships. Eight of the 67 questions cover Process Auditing, 10 cover the Reward System and Safety Culture component, 12 cover Quality as well as Risk Management, 14 cover Command & Control and 11 cover the Communication / Relationships component. Eight of the 67 questions are worded negatively, where a positive response is indicated by a low value. The survey questions utilize a five point Likert rating scale with the following verbal anchors: Strongly Disagree, Moderately Disagree, Neutral, Moderately Agree, and Strongly Agree (The MCAS is included in Appendix C).

3. Procedure

The MCAS is distributed in person. All persons taking the MCAS are told what the survey is, why it is being given and told that their responses are completely anonymous. The Fleet Support Squadron received the MCAS during a safety stand down. Groups of 10 to 15 people were administered to until all available personnel had taken the survey. Each person was given approximately 15 to 20 minutes or more time if needed, to take the survey. The Patrol Squadron MCAS was given one on one going from office to office throughout the squadron's workspaces over a drill weekend. The MCAS was handed out in a workspace and the participants were individually told what the survey was, why it was needed and that their individual responses would not be reported. The workspace MCAS took much longer to administer because participants had a job to do. Some MCAS forms were completed right away, some were collected a few hours later. Throughout the workday and the workspaces, the MCAS were collected on an individual basis. The Combat Support Squadron personnel took the survey at the beginning of a safety brief over a drill weekend. The Squadron personnel were split into two groups of 30 to 40 people. Each group was given approximately 15 to 20 minutes or more time if needed, to take the survey. The MCAS was collected at the time it was completed. For each squadron, each survey was hand numbered for future order.

C. DATA ANALYSIS

1. Data Tabulation

Survey demographics and responses are hand entered into an Excel (Microsoft, 1996) spreadsheet. The spreadsheet consists of rows of respondents and columns of survey questions. The first fifteen columns are for demographics, with another sixty-seven columns representing the actual survey questions. Results are coded in the spreadsheet by assigning scores of 1, 2, 3, 4, or 5 corresponding to the Likert scale of Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree, respectively. Questions 8, 20, 22, 39, 40, 41, and 54 are negative in wording and ask respondents to answer opposite to how they respond to the other questions. Survey questionnaire items that had no response are left blank and were dealt with by S-PLUS (Mathsoft, 1997) as the data is transformed into a SPLUS 4.0 data frame for complete data analysis.

2. Statistical Analysis

Basic summary statistics are developed. Descriptive analysis is conducted on the data to describe basic and general information about the demographic and question results. These results include the distribution of survey participants by rank and service classifications, and the total sample, mean and standard deviation for each of the 67 survey questions. The S-Plus 4.0 (Mathsoft, 1997) program is used for multivariate statistical analyses. Clustering methodologies such as agglomerative nesting and divisive analysis utilizing the S-PLUS functions AGNES and DIANA are used to answer the third research question with the aid of factor analysis. Factor and principal component analyses are performed to answer the second and fifth research questions, utilizing the S-PLUS functions FACTANAL and PRINCOMP.

IV. RESULTS

A. DESCRIPTIVE STATISTICS

Descriptive statistics of survey participants are presented in Table 1. For each participating Squadron, Fleet Support, Patrol and Combat Support, there are two columns. The column titled "All" is representative of all survey participants for the respective squadron. The column with the heading "Maint" pertains to maintenance respondents only. Table 1 lists the numbers of officers, E1/E3, E4/E6, and E7 and above for each squadron as well as the number of TAR, SELRES and USN designated personnel.

Participants	Fleet Support Sqaudron		Patrol Sqaudron		Combat Support Sqaudron		All Sqaudrons	
	All	Maint	All	Maint	All	Maint	All	Maint
Officers	14	1	13	0	14	0	41	1
E1/E3	7	7	2	2	7	7	16	16
E4/E6	77	68	71	67	42	39	190	174
E7+	10	10	7	7	4	4	21	21
Total	**108**	**86**	**93**	**76**	**67**	**50**	**268**	**212**
SELRES	65	47	59	45	34	26	158	118
TAR	42	38	34	31	32	23	108	92
USN	1	1	0	0	1	1	2	2
Total	**108**	**86**	**93**	**76**	**67**	**50**	**268**	**212**

Table 1. Distribution of Survey Participants.

From Table 1, the maintenance personnel involved in taking the survey represent 79 percent of the total survey population. Maintenance E4/E6 enlisted personnel represented a total of 82 percent of the data analyzed in this thesis. This is important to note because most of the maintenance work and work supervision is done at this level.

B. MAINTENANCE RESPONSE STATISTICS

The MOSE component results for maintenance respondents are presented in Tables 2 through 7 (The MOSE component results for all respondents are tabulated in Appendix D). Tables 2 through 7 list the maintenance results for all three Squadrons for each of the six MOSE components. The tables show total respondents for each question (n), average rating for each question on a "1" to "5" Likert scale and the standard deviation for each question. It is interesting to note that average results amongst the squadrons are relatively similar. Also noted is that for the eight questions of the MCAS worded negatively, the respondent's answers reflect as expected.

The first MOSE component presented in Table 2 is Process Auditing. There are eight questions in this component. The only question that raises a concern is number 59 (overall mean = 2.73). All three Squadrons rate this question below neutral, in the disagree direction of the Likert scale. The question entails the use of safety staff to manage personnel at risk. A better, more effective use of safety staff and a higher presence of safety staff within the squadron may be a possible way to influence this perspective in the positive direction. The remaining eight questions are answered positively (mean range = 3.08 to 4.83).

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
1	86	4.42	0.458	76	4.38	0.653	50	4.42	0.758	212	4.41	0.623
2	86	3.79	0.897	76	3.79	0.838	50	3.74	1.121	212	3.77	0.952
3	86	4.47	0.699	75	4.19	0.766	49	4.33	0.774	210	4.33	0.746
4	86	4.41	0.879	75	4.29	0.785	50	4.16	0.889	211	4.29	0.851
5	85	4.60	0.576	76	4.83	0.444	50	4.62	0.667	211	4.68	0.562
46	85	4.25	1.093	75	4.11	0.649	50	4.20	0.782	210	4.18	0.841
59	85	2.66	1.418	76	2.55	1.136	50	2.98	1.237	211	2.73	1.264
67	85	3.18	1.004	75	3.39	0.999	50	3.08	1.175	210	3.21	1.059

Table 2. Process Auditing MOSE Component.

The Reward System and Safety Culture MOSE component is presented in Table 3. Ten questions comprise this component, with two that are negatively worded, questions 41 and 54. These two questions appear to be a problem, but reverse coding shows that they are answered positively (mean range = 3.49 to 4.02, and 3.02 to 3.45 respectively). The other eight questions are all answered positively (mean range = 3.10 to 4.32).

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
6	85	3.51	1.158	76	3.68	0.996	50	3.82	1.155	211	3.67	1.103
7	85	3.93	1.281	75	3.99	0.814	50	3.84	1.167	210	3.92	1.087
18	86	4.24	0.916	76	4.17	0.870	50	3.98	1.078	212	4.13	0.955
19	85	3.35	1.874	76	4.01	0.887	50	4.08	0.922	211	3.82	1.228
36	84	3.37	1.320	74	3.20	1.007	49	3.10	1.141	207	3.22	1.156
41	86	2.51	1.406	76	2.24	1.118	50	1.98	1.040	212	2.24	1.188
53	86	3.64	1.198	76	3.47	0.945	50	3.56	1.091	212	3.56	1.078
54	85	2.66	1.418	76	2.55	1.136	50	2.98	1.237	211	2.73	1.264
58	85	4.14	1.075	76	4.26	0.719	49	4.04	1.172	210	4.15	0.989
60	85	4.31	0.715	76	4.32	0.697	50	4.32	0.913	211	4.31	0.775

Table 3. Reward System and Safety Culture MOSE Component.

The third MOSE component is Quality. This component has twelve questions, with one question, number twenty (mean range = 4.00 to 4.05), requiring reverse coding. All questions in this component, except one, are answered positively (mean range = 3.45 to 4.37). Question 37 (overall mean = 2.82) is answered in a negative manner. This question relates to staffing; Is it sufficient from shift to shift. The Quality component results are presented in Table 4.

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
9	86	4.23	0.577	76	4.20	0.654	50	4.40	0.571	212	4.28	0.601
10	84	3.68	1.160	75	3.61	0.769	50	3.70	0.953	209	3.66	0.961
17	86	4.29	0.632	75	4.20	0.838	50	4.28	0.858	211	4.26	0.776
20	86	1.97	1.281	76	1.95	1.044	50	2.00	1.161	212	1.97	1.162
37	84	2.63	1.344	75	3.07	0.991	50	2.76	1.205	209	2.82	1.180
42	86	3.45	1.757	74	3.80	0.979	50	3.80	1.143	210	3.68	1.293
44	86	4.24	0.987	75	4.28	0.745	50	4.26	1.006	211	4.26	0.913
45	84	4.32	1.040	76	4.29	0.745	50	4.28	0.927	210	4.30	0.904
47	85	4.37	0.830	76	4.42	0.735	50	4.66	0.557	211	4.48	0.707
48	84	3.92	1.354	76	4.26	0.755	50	4.32	0.768	210	4.17	0.959
49	83	3.82	1.467	76	3.93	0.971	50	3.92	1.047	209	3.89	1.162
50	84	3.61	1.567	76	4.05	0.893	50	4.16	1.095	210	3.94	1.185

Table 4. Quality MOSE Component.

Risk Management is the fourth MOSE component and it has twleve questions, with three questions, numbers 12 (mean range = 2.84 to 3.03), 22 (mean range = 3.55 to 3.88), and 40 (mean range = 2.93 to 3.12), requiring reverse coding. All but one of the questions were answered positively (mean range = 2.98 to 4.33). Question 51 (overall mean = 2.78) has negative responses. This question concerns equal workloads and equal stress / fatigue between shifts.. This negative perception may be of some concern. The Risk Management component results are presented in Table 5.

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
11	84	2.98	1.180	74	3.00	0.828	50	3.24	0.847	208	3.07	0.952
12	85	2.97	1.344	75	3.16	1.027	49	2.98	1.145	209	3.03	1.172
21	85	3.93	1.019	76	3.83	0.790	50	3.98	0.915	211	3.91	0.908
22	86	2.45	1.757	76	2.12	0.966	50	2.14	1.125	212	2.24	1.283
23	85	3.75	1.188	76	3.67	0.999	49	3.57	1.155	210	3.67	1.114
24	86	4.33	0.599	76	4.21	0.754	50	4.18	0.873	212	4.24	0.742
40	86	3.07	1.619	74	2.88	0.859	50	2.88	1.223	210	2.94	1.234
51	84	2.54	1.481	73	3.18	0.887	50	2.64	1.156	207	2.78	1.175
55	85	3.46	1.346	75	3.73	1.004	50	3.46	1.092	210	3.55	1.147
61	85	3.99	1.107	76	4.15	0.706	50	4.12	0.961	211	4.08	0.925
62	84	4.12	0.925	76	4.20	0.783	50	4.28	0.784	210	4.20	0.831
63	84	3.76	1.437	76	3.95	1.018	50	4.14	0.948	210	3.95	1.134

Table 5. Risk Management MOSE Component.

Command and Control is the fifth component of the MOSE model. It comprises the largest number (14) of questions in the survey, with question 39 worded negatively.

Reverse coding question 39 (mean range =2.54 to 2.92) shows that it is responded to negatively in the survey. Question 39 deals with passdown between shifts within the command. All other questions in this component were answered positively (mean range = 2.96 to 4.68). Table 6 tabulates the results for the maintenance survey for the Command and Control MOSE component.

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
13	86	4.41	0.621	76	4.28	0.759	50	4.32	0.713	212	4.33	0.698
14	85	3.92	0.910	75	3.93	0.875	50	4.16	0.817	210	4.00	0.867
25	86	4.00	0.918	76	4.05	0.798	50	4.08	0.900	212	4.04	0.872
26	86	3.90	1.036	76	4.13	0.660	50	4.04	0.968	212	4.02	0.888
27	86	3.91	0.932	75	4.08	0.749	50	3.92	0.966	211	3.97	0.882
28	86	3.94	0.950	76	3.95	0.798	50	3.90	0.886	212	3.93	0.878
29	86	3.71	1.173	75	3.27	1.212	50	3.76	1.153	211	3.58	1.179
30	86	3.81	1.259	76	4.08	0.707	50	4.06	0.998	212	3.98	0.988
38	85	3.82	1.242	76	3.72	1.015	50	3.74	1.026	211	3.76	1.094
39	85	3.35	1.541	75	3.08	0.941	50	3.46	1.129	210	3.30	1.204
56	85	4.45	0.703	76	4.47	0.621	50	4.68	0.551	211	4.53	0.625
64	85	4.01	0.964	76	4.00	0.766	50	4.16	0.842	211	4.06	0.857
65	84	3.81	1.264	76	3.96	0.807	50	4.14	0.904	210	3.97	0.992
66	83	2.96	1.206	75	3.07	0.920	50	3.14	0.990	208	3.06	1.039

Table 6. Command and Control MOSE Component.

The final component of the MOSE is Communication / Relationships. This component has eleven questions, with question eight (mean range = 3.23 to 3.70) worded negatively. Questions 34 (overall mean =2.99) and 43 (overall mean = 2.64) show some concern, resulting in response values less than three. The Communication / Relationship component is tabled in Table 7.

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
8	84	2.77	1.575	75	2.39	1.102	50	2.30	1.165	209	2.49	1.281
15	86	3.63	1.531	76	3.33	1.038	50	3.28	1.161	212	3.41	1.243
16	85	3.86	0.956	74	3.53	0.954	50	3.68	0.794	209	3.69	0.901
31	86	3.73	1.257	76	3.40	1.034	50	3.52	1.216	212	3.55	1.169
32	85	4.01	1.083	76	4.34	0.684	50	3.88	1.154	211	4.08	0.974
33	86	3.92	0.970	75	3.96	0.892	50	3.94	0.998	211	3.94	0.953
34	86	2.90	0.918	73	3.16	1.028	50	2.90	1.055	209	2.99	1.000
35	85	3.65	1.612	75	3.43	1.029	50	3.32	1.115	210	3.46	1.252
43	84	2.80	1.440	75	2.48	1.178	50	2.64	1.174	209	2.64	1.264
52	86	3.79	1.203	75	3.99	0.762	50	3.92	0.900	211	3.90	0.955
57	85	3.94	1.151	76	4.03	0.730	50	4.10	1.035	211	4.02	0.972

Table 7. Communication / Relationship MOSE Component.

Each question within the MOSE is answered positively for all participating squadrons. The average for all questions in each MOSE component was computed and is tabulated in Table 8.

MOSE Component	Fleet Support Squadron	Patrol Squadron	Combat Support Squadron	Combined Squadrons
Process Auditing	3.97	3.94	3.94	3.95
Reward System	3.73	3.83	3.78	3.78
Quality	3.88	4.01	4.05	3.98
Risk Management	3.52	3.67	3.63	3.61
Command & Control	3.81	3.85	3.90	3.85
Comm/Functional Relationships	3.59	3.57	3.41	3.56

Table 8. MOSE Component Summary Results.

C. ANALYSIS PROBLEM

The dataset used in this portion of the analysis uses only the Maintenance surveys. Of the total 268 surveys collected, 212 were from Maintainers. These 212 responses are used to form a data matrix, X, to be studied and analyzed using the S-Plus statistical package. If X is n by k, then n = 212, the total number of survey respondents and k = 67, the number of survey questions presented.

The problem is to reduce the existing k MCAS items to a more reasonable number for a full-scale survey. An acceptable number of questions for a survey is in the range of

25 to 40 questions (Fink, 1985). Clustering methods such as agglomerative nesting and divisive analysis are sensible tools for such problems.

These methods belong to the family of hierarchical clustering methods that produce a tree-like hierarchy. This structure is most conveniently visualized through a dendrogram such as the one depicted in Figure 6. The vertical scale is a distance measure that marks the levels at which two clusters are joined to make one. The horizontal is a nominal scale on which the item designators are permuted so that the tree arcs do not cross one another. From the bottom up we can view how the k items are joined to form successive clusters. The use of such information can help provide a dispassionate guide for grouping the 67 items into a more reasonably sized set.

D. AGGLOMERATIVE NESTING (AGNES)

Two S-PLUS algorithms are used, AGNES and DIANA. Agglomerative nesting (AGNES) is discussed first as it is the easier to describe. It is a "bottom up" approach so, initially, there are (k=67) clusters; each single item is viewed as a cluster. First, one selects a distance measure. Suppose euclidian distance is chosen and is initially computed as the distance between each pair of questions. One finds the smallest value of this set and forms a cluster of the two items associated with it. Now, there are k-1 clusters instead of k, and the distance of all items from the new cluster of two must be computed and used to replace the 2 * (k-2) distances of the two selected items from all others that have been supplanted. They are needed no more but there is a choice in defining the new distances. It was chosen to average the distances between all pairs of items, one from each cluster, to obtain a distance figure separating two clusters. This done, again the smallest distance is chosen for forming the next new cluster, etc. The process continues until there is but one cluster consisting of all k items. The user can select the clustering solution that suits him/her. Scanning the vertical scale is often useful for this purpose.

The agglomerative nesting function called "AGNES" in S-PLUS package is used as a first method to cluster the k questions or variables of the Maintenance safety survey into fewer questions. The S-PLUS function "AGNES" is called using the command `agnes(daisy (t(X)),diss=T)`. The S-PLUS function "daisy" is used to calculate the dissimilarity matrix for X. The "diss=T" statement means that a dissimilarity matrix is to be used in the computations to serve as the distance function. This choice corrresponds to the one described.

Results from AGNES are then plotted using the pltree.agnes S-PLUS function. The pltree.agnes function produces a clustering tree of agglomerative hierarchical clustering when it is passed an AGNES object. It creates a plot of a clustering tree. The leaves of the tree are the original objects or in this case, the k questions. Two branches of the tree come together at the distance between the two clusters being merged. Figure 6 shows the clustering tree resulting from the pltree.agnes command.

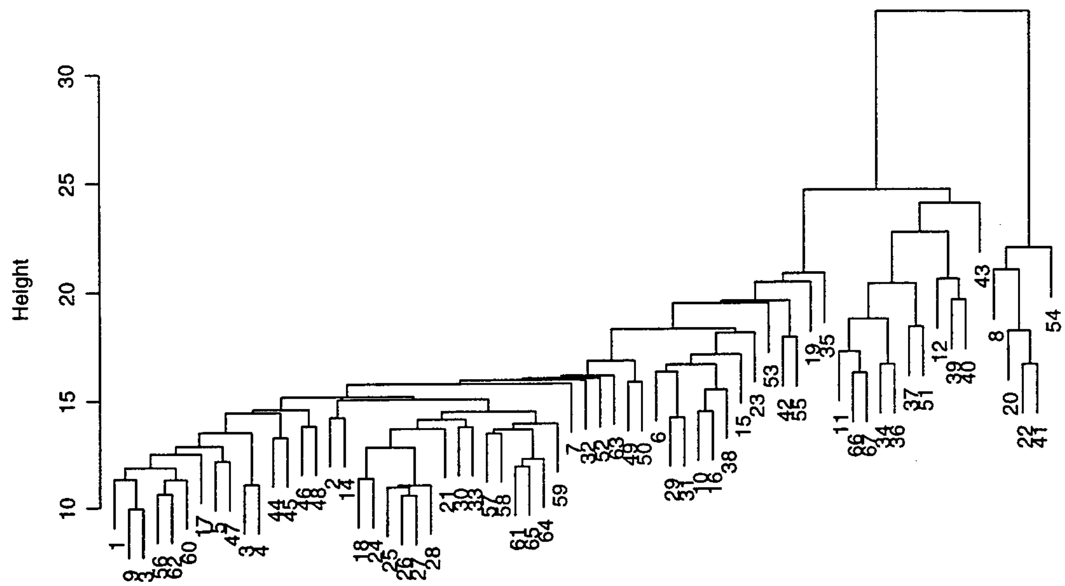

Figure 6. AGNES Clustering Tree.

The AGNES function returns an object containing the following items: order, height, agglomerative coefficient, and a matrix called merge. Order is a vector giving a permutation of the original objects to allow for plotting, in the sense that the branches of a clustering tree will not cross. Height is a vector with the distances between merging clusters at the successive stages. The agglomerative coefficient (ac) measures the amount of clustering structure found in the dataset. More explicitly to each item i, denoted by m(i), the dissimilarity to the first cluster it is merged with, is divided by the dissimilarity of the merger in the final step of the algorithm. The ac value is the average of all the {1-m(i)}. The resulting ac value produced by AGNES is 0.5445873. The AGNES object has a resulting merge matrix, describing the merging of clusters at steps within the clustering process. It provides the numerical support for the dendrogram.

Merge is a (k-1) by 2 matrix, where each row i of merge describes the split at step k-i of the clustering. The merge item returned using AGNES is important. This matrix is a road map for reading the clustering tree plot resulting from the pltree.agnes function. This matrix and the tree plot are used as an aid in clustering the questionnaire items. First, pairs are clustered utilizing the interpretations of the merge matrix. Next, triple and quad clusters are identified. Easily identified pairings, triples and quads are shown in the Table 9. Also shown in Table 9 are the singles, eight questions that do not merge with previously constructed clusters until high in the tree.

Singles		Pairings					Triples		Quads
7	43	2,14	26,27	44,45	10,16	37,51	1,9,13	11,66,67	44,45,46,48
19	52	3,4	29,31	46,48	18,24	39,40	6,29,31	12,39,40	8,20,22,41
32	53	5,47	30,33	49,50	22,41	57,58	10,16,38	56,60,62	19,35,42,55
35	63	9,13	34,36	56,62	42,55	61,65	61,64,65		25,26,27,28
		66,67							

Table 9. AGNES Clustering.

From these identified pairings, additional items were then added by using the corresponding merge information until all questions were covered. Table 10 shows the remaining questions and how they were added to the initial clusters. It shows the questions, identified by the AGNES algorithm, that are near in distance.

(2,14)	(1,5,9,13,17,47,56,60,62)	(11,34,36,66,67)	(46,48)	(37,51)
(3,4)	(6,10,15,16,23,29,31,38)	(8,20,22,41,54)	(49,50)	(39,40)
(30,33)	(44,45,57,58,59,61,64,65)	(18,21,24,25,26,27,28)	(42,55)	

Table 10. Additional AGNES Clustering.

E. DIVISIVE ANALYSIS (DIANA)

The AGNES algorithm is a bottom up approach to hierarchical clustering. The DIANA algorithm reverses this process. It is top down and the resulting tree need not be the same. The distance between clusters is used for explanatory purposes.

The process begins with a single cluster of all items and then considers all possible partitions of the items into two clusters. (It is convenient to think of it in this way, although efficient algorithms exist which do not actually do this.) The pair of clusters selected is the one with the greatest separation. Then the process is repeated using each of the clusters so formed, etc. Ultimately, the cluster will consist entirely of single items. The dendrogram for this method appears in Figure 7. Comparing Figure 6 and Figure 7 it is seen that the trees are quite similar. This is a comforting check.

The divisive analysis function called "DIANA" in the SPLUS package is used as an approach to "cluster" the k questions into a tree. The DIANA function in S-PLUS is called using `diana(daisy(t(X)),diss=T)`, where X represents the data matrix used in AGNES. Again, the S-PLUS function "daisy" is used to calculate the dissimilarity matrix for X. The "diss=T" statement means that the same dissimilarity matrix is to be used in the distance computations.

Results from DIANA are then plotted using the pltree.diana function to look at the clustering results. The S-PLUS function pltree.diana creates a plot of a clustering tree or dendrogram given a DIANA object. The leaves of the tree lead to the k original objects or questions. A branch splits up at the diameter of the cluster being split. Figure 7 shows the resulting tree of "clusters" from the DIANA analysis.

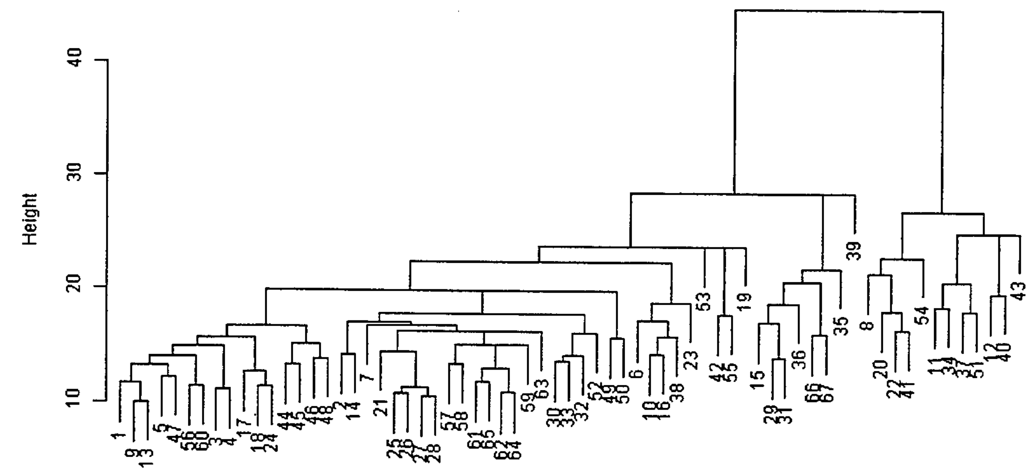

Figure 7. DIANA Clustering Tree.

The DIANA function returns the following items: “order”, “height”, the “divisive coefficient”, and “merge”. Order is a vector giving a permutation of the original objects to allow for plotting, in the sense that the branches of a clustering tree will not cross. Height is a vector with the diameters of the clusters prior to splitting. The divisive coefficient measures the amount of clustering found. More explicitly, for each item i, denoted by d(i), the diameter of the last cluster to which it belonged (prior to being split as a single object), divided by the diameter of the whole set. The dc measure is the average of all {1-d(i)}. The divisive coefficient resulting from DIANA is found to be 0.6559955. Like the AGNES object, the DIANA object has a resulting merge matrix, describing the merging of clusters at steps within the clustering process.

Again, the merge matrix and the tree plot are used as an aid in clustering the questionnaire items. First, pairs clustered are identified and analyzed to see if they make sense. Next, triple and quad clusters are identified. Easily identified pairing are shown in the Table 11.

Singles	Pairings				Triples		Quads
19	2,14	12,40	30,33	56,60	1,9,13	12,40,43	11,34,37,51
23	3,4	18,24	37,51	57,58	10,16,38	20,22,41	19,42,55,53
35	5,47	22,41	42,55	61,65	15,29,31	30,32,33	25,26,27,28
39	9,13	25,26	44,45	62,64	17,18,24		44,45,46,48
43	10,16	27,28	46,48	66,67			61,62,64,65
53	11,34	29,31	49,50				

Table 11 DIANA Clustering.

From these identified pairings, additional items are then added using the corresponding merge information until all questions are covered. Table 12 shows the remaining questions and where they are added to the initial pairings. It shows the questions, identified by the DIANA algorithm, that are near in distance.

(1,5,9,13,47,56,60)	(57,58,59,61,62,63,64,65)	(8,20,22,41,54)	(6,10,16,23,38)	(3,4)
(11,12,34,37,40,43,57)	(15,29,31,35,36,39,66,67)	(30,32,33,52)	(2,7,14)	(49,50)
(44,45,46,48)	(21,25,26,27,28)	(19,42,53,55)	(17,18,24)	

Table 12. Additional Clustering with DIANA.

Comparing the two S-PLUS methods of AGNES and DIANA shows some interesting aspects. First, by comparing the two clustering trees, the shape of each tree is very similar. The initial pairings found in the two methods are alike also. Of the 23 initial pairings from DIANA and the 21 pairings from AGNES, 17 are common to both. Moving up the clustering tree one level, more similarities are seen. Furthermore, by looking at higher levels of the two clustering trees, clusters of three or four questions form. Table 13 shows the common pairings, triples and quads found between the two methods.

Pairings					Triples	Quads
2,14	9,13	22,41	37,51	46,48	1,9,13	25,26,27,28
3,4	10,16	29,31	42,55	49,50	10,16,38	8,20,22,41
5,47	18,24	30,33	44,45	57,58	61,64,65	44,45,46,48
61,65	66,67					

Table 13. Common Clusters Between DIANA and AGNES.

F. PRINCIPAL COMPONENTS / FACTOR ANALYSIS

The Principal Component / Factor Analysis material will help complete the questionnaire size reduction process. Principal Component Analysis was conducted on the dataset using the S-PLUS software package. The S-PLUS command of princomp(X,scores=T,cor=T) was used in the analysis. X is the 212 by 67 matrix of survey responses and "cor=T" means that the principle component analysis is to be based on the correlation matrix. The resulting principle component output was plotted using a screeplot, a special S-PLUS barplot function for the class princomp. The S-PLUS function screeplot(prin2.out) was used. It shows the contribution of each factor to the total variance. Figure 8 shows the resulting screeplot.

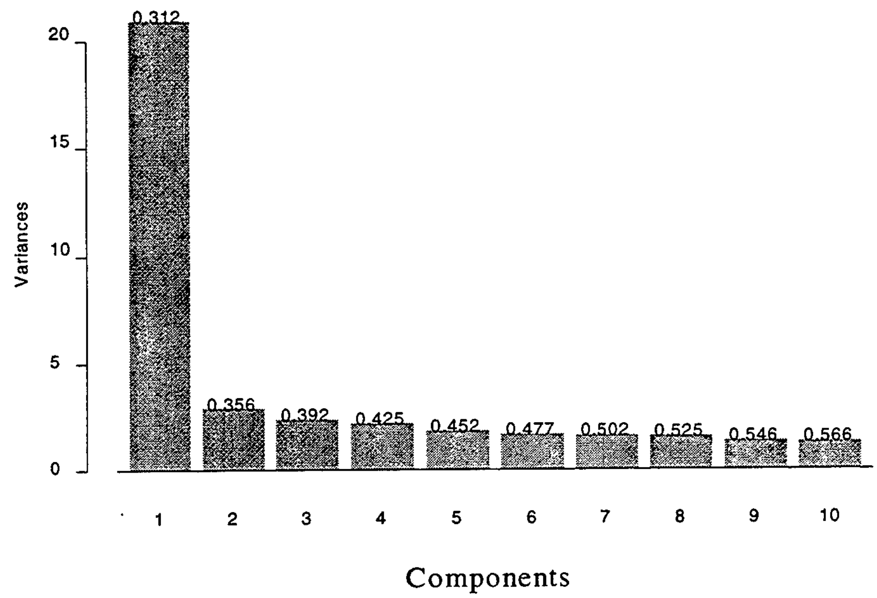

Figure 8. Principal Component Screeplot.

Above each bar in the plot are the cumulative fractions of the variance. The variance is sharply the highest on the first component and spread rather evenly over the remaining components. This shows evidence that the survey data is dominated by one dimension. Much of the variability is captured in the first component. This and Factor Analysis is used to assist in answering research questions three and five.

Factor analysis on the data is performed using S-PLUS. The S-PLUS command of factanal(X,factors=6,method="principal", rotation="varimax") was used. Again, X is the 212 by 67 matrix of survey responses, six factors were fit, using varimax rotation as the method of aligning the factors in a six dimensional space. The "factors=6" input specifies the number of factors in the solution. An object of class factanal results.

The factanal class results from fitting factor analysis models. This class has certain properties that are relevant to analyze. An important property is "loadings." Loadings is an orthogonal matrix that gives the loadings for each factor, each column being linear combinations of the columns of X for the corresponding factor. Another property of the factanal class is uniqueness. The variance of each item is decomposed into the part that is common to the factor solutions and the part that is unique to that item. The loadings and uniquenesses for each question in the corresponding components of the MOSE are presented in Tables 14 through 19.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
1	0.462	0.306		0.149	0.176		0.6381
2	0.337	0.278	0.189	0.219	0.263		0.6553
3	0.525	0.281	-0.133	0.102	0.268	-0.147	0.5263
4	0.452	0.214		0.131	0.230	-0.140	0.6555
5	0.478	0.107		0.167		0.195	0.6862
46	0.612	0.117	0.146				0.5897
59	0.234	0.596	0.243	0.133	0.148		0.4885
67	0.143	0.339	0.436		0.152		0.6506

Table 14. Factor Loadings for Process Auditing Component.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
6	0.273	0.216	0.378	0.207	0.338		0.5693
7	0.401	0.287	0.180	0.267	0.322		0.5456
18	0.459	0.313		0.297	0.384		0.4447
19	0.366		0.128	0.139			0.8288
36		0.314	0.117	0.329	0.441	-0.160	0.5576
41	-0.402	-0.213	0.116	-0.253		-0.455	0.5007
53	0.239	0.131		0.202	0.277	-0.105	0.7925
54	-0.179	-0.188		-0.372		-0.165	0.7532
58	0.249	0.593	0.152	0.310	0.149		0.4392
60	0.282	0.625	0.112	0.204	0.224	0.133	0.4073

Table 15. Factor Loadings for Reward and Safety Culture.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
9	0.507	0.207	0.200		0.227		0.5898
10	0.440	0.141	0.373		0.284	-0.100	0.5573
17	0.617	0.221		0.133	0.250	0.101	0.4796
20	-0.222	-0.327	0.116	-0.258		-0.464	0.5402
37		0.118	0.537		0.184	0.121	0.6469
42	0.276	0.147	0.412	0.121		0.245	0.6564
44	0.520	0.239	0.124	0.189		0.181	0.5830
45	0.469	0.159	0.154			0.152	0.6991
47	0.657	0.188					0.5148
48	0.567	0.115	0.461	0.143			0.4258
49	0.425	0.215	0.238	0.250	0.214		0.6017
50	0.401	0.333	0.410	0.205		0.152	0.4908

Table 16. Factor Loadings for Quality.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
11		0.129	0.343		0.114	-0.275	0.7637
12				0.166		-0.365	0.8236
21	0.572	0.158		0.226	0.256		0.5284
22	-0.243	-0.146		-0.293		-0.473	0.6092
23	0.162	0.252	0.149		0.363	0.144	0.7275
24	0.487	0.33		0.415	0.194		0.4371
40			-0.128			-0.445	0.7717
51			0.496	0.178		0.101	0.6977
55	0.19	0.33	0.414	-0.112	0.193	0.312	0.5364
61	0.239	0.638	0.321	0.157	0.176		0.3709
62	0.365	0.591	0.305	0.135	0.192	0.12	0.3550
63	0.372	0.418	0.225	0.246	0.178	0.167	0.5159

Table 17. Factor Loadings for Risk Management.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
13	0.483	0.240		0.158	0.272	0.183	0.5747
14	0.415	0.280	0.287	0.101	0.256	0.104	0.5800
25	0.330	0.301	0.165	0.553	0.131	0.109	0.4384
26	0.328	0.338	0.258	0.609			0.3318
27	0.417	0.155	0.218	0.642	0.166		0.3063
28	0.376	0.327	0.206	0.563	0.147		0.3690
29	0.338	0.198	0.213	0.176	0.523		0.4972
30	0.388	0.248	0.316	0.312	0.246	0.165	0.5029
38	0.378	0.131	0.335		0.454	0.131	0.5032
39		0.107	-0.108			-0.372	0.8253
56	0.314	0.485	0.229	0.183	0.108	0.195	0.5305
64	0.238	0.609	0.211	0.231	0.193		0.4305
65	0.210	0.587	0.387	0.141	0.103		0.4293
66	0.158	0.196	0.579		0.122		0.5808

Table 18. Factor Loadings for Command and Control.

Question	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
8	-0.160	-0.166	-0.107	-0.268	-0.101	-0.295	0.7663
15	0.136	0.264	0.337	0.159	0.521	0.120	0.4876
16	0.449	0.263	0.199		0.441		0.4908
31	0.206	0.226	0.248	0.279	0.621		0.3735
32	0.339	0.142	0.252	0.307	0.122		0.6877
33	0.336	0.417	0.156	0.372	0.191		0.5109
34		0.122	0.232	0.320	0.317	-0.145	0.7043
35	0.300				0.348		0.7644
43					0.166		0.9669
52	0.441	0.181	0.308	0.208			0.6322
57	0.185	0.585	0.122	0.195	0.220	0.228	0.4701

Table 19. Factor Loadings for Commuinication / Relationships.

For each component, the questions having the maximum loading over the six factors are analyzed. As true in the principle component analysis, there is one factor, Factor one, which had the most loadings having the maximum value. This analysis, with results shown in Table 20, shows the relationships between the factors resulting from the factor analysis and the MOSE components. Of the 67 questions, 25 of them load the highest in factor one. This provides quantitative information on these items that are represented in the single most important factor dimension.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Component 1	1,2,3,4,5,46	59	67			
Component 2	7,18,19	58,60	6	54	36,53	41
Component 3	9,10,17,44,45,47,48,49		37,42,50			20
Component 4	21,24	61,62,63	11,51,55		23	12,22,40
Component 5	13,14,30	56,64,65	39,66	25,26,27,28	29,38	
Component 6	16,32,52	33,57	15	34	15,16,31,34,35,43	8

Table 20. Questions and Factors Loadings Broken Out by MOSE Component.

Table 21 shows the distribution of the questions over the Factors and MOSE components resulting from the factor analysis. Interesting to note is the number of questions that belong to factor 1. Twenty five of the 67 questions in the MCAS fall into the first factor. The remaining factors have loadings with various signs and provide contrast type information about the items that dominate them.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Component Totals
Component 1	6	1	1	0	0	0	8
Component 2	3	2	1	1	2	1	10
Component 3	8	0	3	0	0	1	12
Component 4	2	3	3	0	1	3	12
Component 5	3	3	1	4	2	1	14
Component 6	3	2	0	1	4	1	11
Factor Totals	25	11	9	6	9	7	67

Table 21. Distribution of Questions From Factor Analysis.

Also interesting to study is the cumulative distribution function of the uniquenesses for each question resulting from the factor analysis. This is important to study because the questions with low uniqueness in the large, have their content represented by other questions. The questions with high uniqueness have individual dominating status. From this, one may be able to identify questions that can be eliminated because they may be non-contibutors. Also, we can identify questions of high uniqueness, which either should be retained as singletons, or identified as dominating the group to which they belong. Figure 9 is the resulting S-PLUS CDFDISC function plot of the sorted uniquenesses and associated probabilities (Appendix E shows the S-PLUS CDFDISC function code).

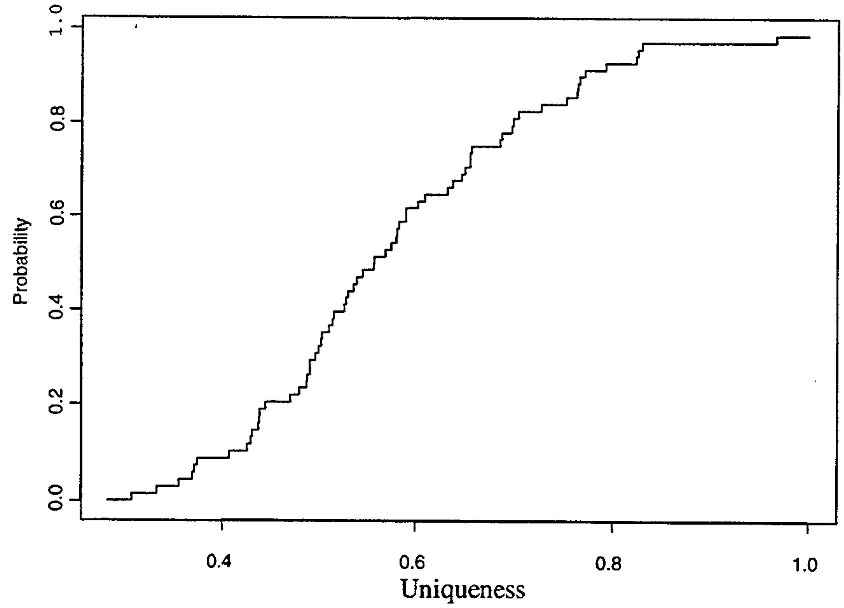

Figure 9. Question Uniqueness Empirical CDF.

Looking at the plot above gives a good view of the uniqueness for the questions. Note the flat spot appearing in Figure 9 at the 0.4 uniqueness level on the x-axis. The questions relating to these uniqueness values are possible candidates for elimination since they all have relatively low uniqueness. Below is Table 22 showing the seven questions whose uniqueness fall near or below the 0.4 value.

Question	Uniqueness
26	0.3318
27	0.3063
28	0.3690
31	0.3735
60	0.4073
61	0.3709
62	0.355

Table 22. Questions with Low Uniquenesses.

There is also a flat area Figure 9 at the 0.75 uniqueness level on the axis identifying questions with high uniqueness relative to the entire set. All uniquenesses to the right of 0.75 relate to those having a relatively high uniqueness. There are ten such questions. Table 23 identifies the ten questions showing the uniqueness values for each.

Question	Uniqueness
8	0.7663
11	0.7637
12	0.8236
19	0.8288
35	0.7644
39	0.8253
40	0.7717
43	0.9669
53	0.7925
54	0.7532

Table 23. Questions with High Uniqueness.

All of this information is useful to aid the researcher in making informative decisions about the items in the data. Each of the above areas of analysis are used in conjunction with one another to obtain the goal of a reduced set of questions to be used in an improved and modified MCAS.

G. QUESTION ANALYSIS

The S-Plus functions AGNES, DIANA, PRINCOMP and FACTANAL assist the researcher in making decisions or objective choices about the items. These will be viewed for reasonableness based on subjective knowledge. The stability of these choices and the results from the analysis are also influenced by the relatively small sample size involved in this study. With this in mind, the questions are studied using the computer-aided output from the previous sections. The prototype MCAS had questions that required reverse coding. It is recommended these questions be rephrasedto read in a positive aspect. (Appendix H lists these questions and the recommended modifications.)

Decision rules need to be identified as to how the downsizing of the MCAS is approached. First, the seven questions identified with low uniqueness are removed. Likewise, questions identified, as having high uniqueness, will be retained. Secondly, all pairs that are the same in both AGNES and DIANA are studied for combination or to see if the questions can be reworded to make one out of the two. This done, the next step is to take all triples and then quadruples identified by the clustering algorithms and look for sensible combinations or removal of questions. At the completion of this, the remaining questions that have not been grouped or clustered will be studied for further sensible reduction.

Questions having low uniqueness are eliminated. There are seven such questions that have been identified in Table 22. The elimination of these seven questions results in a remaining pool of 60 questions. Furthermore, we retain the ten questions identified in Table 23 that have high uniqueness. This leaves 50 questions for continued analysis. Next, the cluster analysis results from AGNES and DIANA are used for combining questions that are answered in similar ways or show redundancy.

Questions paired up that are common to both the AGNES and DIANA methods are analyzed to see if the pairings can be combined easily. Here, questions are paired up due to their relative closeness resulting from the computer-aided output. Questions are studied and if sensible, can be joined with the conjunction "and" or reworded to capture the intent of the original questions. For example, the first pairing from Table 13 is the pair (9,13). By rewording these questions slightly, a new question results that replaces the two questions with one.

This process is done for all identified clusters in Table 13 as well as possible clusters from Tables 9 and 11. Table 24 lists these groupings. Appendix F gives the suggested rewording of these newly formed questions to be included in the suggested MCAS.

Nineteen questions are suggested as candidates for combining, rewording or grouping that reduce the MCAS question total by an additional 24 questions. A sensible pairing is made from two questions having high uniqueness. DIANA identifies pair (19,53) as a cluster and AGNES shows agreement in that the dendrogram has the pairing in close proximity to one another. This pair belongs to the same MOSE component and the two questions have the same intent, thus the two are combined into one. Question 11 also had high uniqueness but it was sensible to cluster it as noted in Table 24.

1,9,13	11,36,59,67	20,22	49,50
2,14	10,66	30,33	52,56
3,4	16,38	42,55	57,58
5,47	18,21,24	37,51	64,65
6,23	19,53	45,46,48	

Table 24. Suggested Question Groupings.

Nine singletons result in this process. These questions neither clustered with others nor seemed reasonable to combine with any other question in the MCAS. These singletons are presented below in Table 25.

7	25	41
15	29	44
17	34	63

Table 25. Original Questions Remaining.

By combing the results in the first step, deleting the questions with relatively low uniqueness and then combining questions using the cluster analysis results, the MCAS reduces to 35 questions; seven from the high uniqueness, 19 from the clustering or rewording, and an additional nine as singletons. There is a judgement call here, and given the data and the questions, this seems to be as far as one can go without adding additional scrutiny to the study. Table 26 gives the suggested mapping of the 67-question prototype MCAS to a suggested 35-question MCAS. The P-Type column contains the ordinal number of the item in the original 67-question MCAS, and the Mapped column displays the ordinal number in the suggested 35-question MCAS.

P-Type	Mapped	P-Type	Mapped	P-Type	Mapped	P-Type	Mapped	P-Type	Mapped	P-Type	Mapped	P-Type	Mapped
1	6	11	8	21	13	31	Deleted	41	25	51	22	61	Deleted
2	1	12	9	22	15	32	Deleted	42	26	52	31	62	Deleted
3	2	13	6	23	16	33	19	43	27	53	14	63	34
4	2	14	1	24	13	34	20	44	28	54	32	64	35
5	3	15	10	25	17	35	21	45	29	55	26	65	35
6	16	16	11	26	Deleted	36	8	46	29	56	31	66	7
7	4	17	12	27	Deleted	37	22	47	3	57	33	67	8
8	5	18	13	28	Deleted	38	11	48	29	58	33		
9	6	19	14	29	18	39	23	49	30	59	8		
10	7	20	15	30	19	40	24	50	30	60	Deleted		

Table 26. Prototype MCAS Questions Mapped to Suggested MCAS Questions.

V. CONCLUSION

A. FINDINGS

The existing MOSE can be used to model or capture the maintainer's perspective, with modifications presented in this thesis. The close-ended questions, after tailoring them towards the maintainer, conformed to the existing MOSE components quite readily. However, an additional component, Communication / Relationships, was added to make the MOSE maintenance specific. Results of the prototype MCAS were positive in nature for all six of the adapted MOSE components except for a few questions that raised concern and these are listed in Table 27. These questions may possibly identify areas that need strengthening within the squadrons.

Question	Fleet Support Squadron	Patrol Squadron	Combat Support Squadron	Combined Squadrons
59	2.66	2.55	2.98	2.73
37	2.63	3.07	2.76	2.82
51	2.54	3.18	2.64	2.78
39	2.65	2.92	2.54	2.7
34	2.9	3.16	2.9	2.99
43	2.8	2.48	2.64	2.64

Table 27. Questions That Raise Concern.

There are no discernable differences identified between the squadrons that were surveyed. A consenus between all participating squadrons was that of favorable results for all MOSE components. Agglomerative nesting and Divisive Analysis together with Prinicpal Components and Factor Analysis were tools used to identify clusters of questions that were similar. Although the Factor Analysis shows that most of the questions load on factor one, there is no evidence against the structure of the maintenance adapted MOSE. Redundant questions were eliminated and questions with similar intent were combined. Thus, the prototype MCAS was reduced from 67 to 35 questions, shortening the survey to a more practical length, requiring less time to complete. The finalized MCAS is listed in Appendix I.

B. OTHER AREAS OF CONCERN

There are numerous future studies that can further this thesis. One such task would be to alter the questionnaire in order to use it with the Marine Corps, using "Marine" specific terms. Also, this study could be further investigated by surveying active duty Naval Aviation Squadrons to make comparisons of the results with the Reserve Squadron results presented in this study. The Marine Squadron results could be compared to Navy Squadrons to see if there is a statistical difference between the two. Another task would be to administer the survey to Regular active duty Squadrons and do a comparison between Reserve and active duty Squadrons. Also, other analysis methods could be used to validate this study and its results.

C. SUMMARY

The Class A flight mishap rate has leveled off over the past decade. Human Factors studies are increasing as they tyy to identify additional areas where intervention could lead to further reductions of the Class A flight mishap rate. This thesis is part of a Human Factors related study specifically aimed at Maintenance operations within Naval Aviation. The resulting survey is to be used as a tool for commanders to assess the effectiveness of Naval Aviation maintenance operations in the management of risk.

APPENDIX A. EXISTING MOSE COMPONENTS

COMPONENT 1: PROCESS AUDITING

1. Conducts periodic safety reviews and inspections.
2. Conducts timely reviews and updates of safety practices and operating standards.
3. Uses a systematic process to set training goals and to review flight qualifications.
4. Uses Human Factors Councils and Boards to identify and screen high-risk aviators.
5. Makes effective use of Flight Surgeon for assessing significant stress reactions, and possible unsafe attitudes of individuals as well as routine medical screening.

COMPONENT 2: REWARD SYSTEM

1. Recognizes safety achievement through social praise, and formal awards and incentives.
2. Safe behavior is reinforced as a cultural norm (by command emphasis and peer pressure).
3. Takes timely action (s) to appropriately discipline unsafe behavior and attitudes.
4. Encourages everyone to be safety conscious and to identify safety problems.
5. Encourages everyone to report safety discrepancies without fear of negative repercussions.

COMPONENT 3: QUALITY

1. Sets high quality standards as an organizational goal.
2. Publishes quality standards and quality control procedures.
3. Monitors quality and corrects deviations from established quality standards.
4. Gains reputation for high-quality performance in comparison to reference standards or comparable organizations.

COMPONENT 4: RISK MANAGEMENT

1. Has accurate perception of actual operational mission risks.
2. Uses a systematic method for managing risk.
3. Risks of mission operations are acknowledged and minimized.
4. Safety risk decisions are made at the proper level (by most qualified people).
5. Resources (time, budget, staffing, and equipment) are adequate for performance of mission and organizational workload.
6. Does not compromise safety to get the work done or to accomplish the mission.

COMPONENT 5: COMMAND AND CONTROL

1. Supervisors openly demonstrate a commitment to safety.
2. Supervisors clearly communicate safety goals and policies.
3. Supervisors are directly involved in safety management.
4. Safety is considered as an integral part of mission accomplishment.
5. The command establishes and uniformly enforces operating standards.
6. There is frequent interaction between command supervisors and staff.
7. There is good communication flow up and down the command chain.
8. Safety training is emphasized throughout the command.
9. The status and respect for the safety officer's position are high.
10. Personnel turnover is not high enough to affect a command's ability to maintain "corporate" knowledge and the core cultural values of the organization.
11. Supervisors provide adequate guidance and counseling on safety matters.
12. Formal rules and procedures are followed, whether or not command supervisors are physically present.
13. There is redundancy, multiple coverage or adequate safety backups for high-risk operations.
14. Personnel in the command conduct continuous proficiency training.
15. Training incorporates safety guidelines and safeguards.
16. Leadership has vision and understands how to create a positive climate.
17. The prevailing values, beliefs, attitudes, and norms (culture) promote safe behavior/discourages unsafe behavior.
18. Leadership sets example for written policy, standards, proper procedures, and acceptable norms of behavior.
19. The command clearly establishes responsibility and accountability, for safe flight operations at all levels.
20. Command leaders have an accurate perception of the motivation, morale, and job satisfaction level of their people.
21. Command leadership reacts well, and readily adapts to unexpected changes.

PROPOSED COMPONENT 1: PROCESS AUDITING

1. My command adequately reviews and updates safety practices.
2. The command has a dedicated program that targets individual training deficiencies.
3. My command monitors maintainer qualifications.
4. Support equipment licensing is monitored in this command.
5. Tool control is taken seriously at my command.
6. CDIs/QARs routinely monitor maintenance evolutions.
7. My command uses safety staff to manage personnel at risk.
8. The command uses medical staff to manage occupational hazards and personnel at risk.

PROPOSED COMPONENT 2: REWARD SYSTEM AND SAFETY CULTURE

1. My command recognizes individual safety achievement through rewards and incentives.
2. Unprofessional behavior is not tolerated in the maintenance department.
3. Supervisors encourage reporting safety concerns without fear of retribution.
4. Supervisors discourage violations of SOPs, or NAMP guidelines.
5. My MO/MCPO understands if I feel uncomfortable performing maintenance duties due to personal issues.
6. Violations of SOP, NAMP guidelines, or other procedures are common in my command.
7. Peer influence discourages violations of SOP, NAMP guidelines or other procedures.
8. Personnel are uncomfortable telling supervisors about personal problems including illness.
9. Individuals feel free to report safety violations, unsafe performance, or other unsafe behavior.
10. Our command climate promotes safe maintenance and flight operations.

PROPOSED COMPONENT 3: QUALITY

1. My command has established standards and maintains quality control.
2. CDIs/QARs are sought after positions in my command.
3. Inspectors perform all required actions before sign off.
4. To meet operational commitments, supervisors allow "cutting corners."
5. Maintainer staffing is sufficient from shift to shift.
6. Proper tools and equipment are available, servicable and used.
7. Required publications are available, current and used.
8. Maintenance gripes are either corrected or addressed prior to flight.
9. My command has a reputation for quality maintenance.
10. The QA division is respected in my command.
11. Signing off PQS/JQRs/PARs is taken seriously and not gun decked.
12. Maintenance quality on detachments is the same as that in homeport.

PROPOSED COMPONENT 4: RISK MANAGEMENT

1. My command temporarily restricts maintainers who are having personal problems.
2. Based upon my command's current manning and assets, it is over-committed.
3. Supervisors manage hazards associated with maintenance and flight line operations.
4. Supervisors are more concerned with mission completion than aircraft maintenance.
5. My division CPO is aware of individual daily workload requirements.
6. Unsafe conditions are recognized and addressed by M/C, Q/A, or W/C supervisors.
7. Personnel turnover negatively affects my command's ability to operate safely.
8. Day and night check have equal workload and are equally stressful/fatiguing.
9. I am provided adequate resources (time, personnel, and equipment) to accomplish my job.

10. Safety decisions are made at the proper command levels.
11. Safety is part of maintenance planning, and additional training/support is provided as needed.
12. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.

PROPOSED COMPONENT 5: COMMAND AND CONTROL

1. My command ensures all maintainers are responsible and accountable for safe maintenance.
2. My command ensures the uniform enforcement of SOPs among unit maintenance personnel.
3. Supervisors communicate command safety goals, programs, and procedures.
4. Supervisors are actively involved in the safety program and management of safety matters.
5. Supervisors set the example for compliance to established maintenance standards.
6. Supervisors are responsive to unexpected changes and anticipate potential hazards.
7. W/C supervisors are respected by the maintenance chief/officer.
8. All maintenance evolutions are properly supervised by qualified personnel.
9. Maintenance control is effective in managing all maintenance activities.
10. Multiple job assignments and collateral duties adversely affect maintenance.
11. In my command, we believe safety is an integral part of all maintenance and flight line operations.
12. Safety education and training in my command are comprehensive and effective.
13. The safety department is respected by supervisors and maintainers.
14. Maintenance Safety Petty Officer is a sought after billet in my command.

PROPOSED COMPONENT 6: COMMUNICATION / RELATIONSHIPS

1. My command has a problem with passdown between shifts.
2. Within my unit, good communication flow exists up and down the chain of command.
3. Coordination is conducted between the M/C, W/C and QA prior to incorporation of TDs.
4. Work center supervisors, division CPOs and M/C work well together.
5. Aircraft moves are briefed and detailed personnel are qualified.
6. Maintainers are briefed on potential hazards associated with maintenance activities.
7. My supervisor shields me from outside pressures, which may affect my work.
8. QARs are never pressured by the maintenance supervisors to sign off a gripe.
9. Maintenance Control never troubleshoots aircraft discrepancies.
10. QARs are viewed as helpful, and QA is not "feared" in my command.
11. I feel I get all information (internal and external) required to perform my job safely.

APPENDIX B. CANDIDATE MAINTENANCE QUESTIONS

1. My command has a reputation for high quality maintenance.
2. My command is genuinely concerned about safety.
3. Command leadership is successful in communicating its safety goals to unit personnel.
4. My command provided a positive climate that promotes safe maintenance and flight operations.
5. Command leaderships is actively involved in the safety program and management of safety matter.
6. Command leadership sets the example for compliance to established standards.
7. My command conducts adequate reviews and updates of safety practices.
8. My command ensures that all unit members are responsible and accountable for safe maintenance and flight operations.
9. Command leadership permits "cutting corners" to get the job done.
10. Safety decisions are made at the proper levels by most qualified people in my command.
11. Command leadership encourages reporting safety discrepancies without fear of negative repercussions.
12. Individuals in my command are willing to report information regarding safety violations, marginal performance, or other unsafe behavior.
13. My command has a defined process to set training goals and to review performance.
14. Loss of experienced personnel has negatively affected my command's ability to operate safely.
15. Command leadership willingly assists in providing advice concerning safety matters.
16. My command has established quality standards and strives to maintain quality control.
17. Command leadership considers safety issues during the formation and execution of operational and training plans.
18. Command leadership has a clear picture of the risks associated with its maintenance and flight line operations.
19. My command takes the time to identify and assess risks associated with its maintenance and flight line operations.
20. My command does a good job managing risks associated with its maintenance and flight line operations.
21. My command closely monitors proficiency and currency standards to ensure maintenance personnel are qualified to perform their assigned tasks.
22. My command provides adequate safety backups to catch possible human error during hi-risk tasks.
23. Command leadership reacts well to unexpected changes to its plans.
24. In my command, we believe safety is an integral part of al maintenance and flight line operations.
25. My command has increased the chances of a mishap due to inadequate or incorrect risk assessment.

26. My command does not hesitate to temporarily restrict from maintenance tasks individuals who are under high personal stress.
27. I am adequately trained to safely conduct all of my assigned tasks.
28. I am provided adequate resources (time, staffing, budget, and equipment) to accomplish my job.
29. No equivalent.
30. My collateral duties adversely affect my ability to accomplish my maintenance tasks.
31. Morale and motivation in my command are high.
32. My command ensures the uniform enforcement of operating standards among unit personnel.
33. I have adequate time to prepare for my assigned tasks.
34. Command leadership is effective at discouraging violations of operating procedures, NAMP guidelines or general maintenance discipline.
35. In my command, peer influence is effective at discouraging violations of operating procedures, NAMP guidelines, or general maintenance discipline.
36. My command's SOP is effective at promoting safe maintenance and flight line operations.
37. I am very familiar with the policies and regulations contained in the OPNAVINST 4790.2 series.
38. Rest standards are enforced in my command.
39. Based upon my command's personnel and other assets, the command is over committed.
40. In my command, PC/CDI/QAR tests and monitors are conducted as intended, to candidly assess maintainer qualifications.
41. Strict enforcement of NAMP standards is upheld in my command.
42. In my command, anyone who intentionally violates NAMP/NAMSOP is swiftly corrected.
43. In my command, violations of operating procedures, NAMP regulations, or general maintenance or flight line operation discipline are rare.
44. Within my command, good communication flow exists up and down the chain of command.
45. My command has good two-way communication with external commands.
46. Procedures in my command are adequate to effectively conduct Human Factors Councils or Boards.
47. Human Factors councils have been successful in identifying maintenance members who pose a risk to safety.
48. Human Factors Boards have been successful in managing the high-risk maintainer.
49. My command makes effective use of the flight surgeon to help identify and manage high-risk personnel.
50. My command recognizes an individual's safety achievements through rewards and incentives.
51. Safety education and training are adequate in my command.
52. The safety department is a well-respected element of my command.
53. The Maintenance Safety Petty Officer position is a sought after billet in my command.

54. My commands safety department keeps me well informed regarding important safety information.
55. My command has received adequate guidance, information, and training regarding Maintenance Risk Management.
56. My command has begun to implement MRM processes into decision-making at all levels.
57. The QA division is well respected in my command.
58. CDI is a sought after position in my command.
59. QAR is a sought after position in my command.
60. The EAWS program is considered to have integrity in my command.
61. A coordinated brief is conducted between M/C, the W/C and QA prior to incorporating the AFB/AFC's, etc.
62. CDI/QARs perform routine monitors of maintenance evolutions.
63. Requirements for PPE use are strictly enforced.
64. The qualifying of CDI/QAR's is considered to be a fair process.
65. Decisions on who should be CDI/QAR are made fairly and without favoritism.
66. Support equipment licensing is closely monitored.
67. Requirements for having SE licenses are taken seriously.
68. The "signing-off" of PQS/JQRs/PARs, etc. is taken seriously and managed with integrity. (not gun decked)
69. Maintenance Control provides for adequate time to complete the job when assigning tasks.
70. Performing incomplete daily inspections is not tolerated in my command.
71. Inspectors never sign off the "inspected by" block without physically performing the required inspection.
72. Work center supervisors work well with M/C.
73. W/C supervisors are respected by maintenance management in my command.
74. W/C supervisors are respected by the "troops" in my command.
75. W/C supervisors are always asked their opinion by M/C.
76. QA is a "feared" organization in my command.
77. All participants involved in an aircraft move are briefed prior to commencing the move.
78. All maintenance evolutions are well supervised.
79. Maintenance evolutions are OVER supervised.
80. Anyone in my command can stop a maintenance evolution if they feel that an unsafe condition exists.
81. All pilots strictly follow plane captain directions/signals.
82. Work center shift passdowns are conducted face to face.
83. Daily maintenance meetings encourage feedback from work centers.
84. All work centers utilize a written passdown log.
85. Division CPOs ensure 100% participation at monthly maintenance safety meetings.
86. Workers with "bad attitudes" are not permitted to work on or around aircraft or other equipment.
87. Utilizing someone's NALCOMIS password is strictly prohibited.
88. Maintenance Control is ALWAYS in control of maintenance.

89. I have confidence that all personnel are qualified to perform their assigned tasks.
90. "Down" gripes are taken seriously by QA.
91. "Down" gripes are taken seriously by M/C.
92. Repeat gripes are monitored by QA and regarded as serious.
93. Publications are always used when performing maintenance.
94. Maintenance Control never troubleshoots from behind the M/C counter.
95. Plane captains always carry daily decks when performing daily inpsections.
96. A799s are taken seriously.
97. Maintenance training is conducted regularly and taken seriously by maintenance management.
98. CPO's are regarded as the technical experts and get involved in troubleshooting tough gripes.
99. CPO's over supervise maintenance tasks.
100. Tool Control is taken seriously at my command.
101. The maintenance control chief is respected.
102. My CO is proud of the maintenance department.
103. Squadron pilots feel comfortable flying the aircraft in this command.
104. Our maintenance department is considered to be the best in the wing.
105. Short cuts are tolerated when the flight schedule dictates.
106. The maintenance department works for the operations department.
107. The goals of the maintenance department are clearly defined.
108. Command leadership is more concerned with mission completion that aircraft material conditions.
109. PPE is available for use when needed.
110. Most maintenance is performed by NX.
111. NX maintainers are considered to be proficient.
112. NX maintainers are considered to be as professional as DX.
113. "Khaki presence" is evident at this command.
114. NX is well represented with CPO's.
115. Shortcuts are tolerated more at night than DX.
116. Working nights is more risky than working days.
117. Maintainers would never be put in an unsafe situation to make the flight schedule.
118. Maintenance performed on detachments is a lesser quality than that at homeport.
119. W/C supervisors are allowed to run their shops without interference from M/C.
120. W/C supervisors feel pressure from M/C.
121. Maintenance is only performed "by the book."
122. Work priorities are clearly set at the shift change maintenance meetings.
123. Use of overdue calibration equipment is not tolerated.
124. Maintenance personnel are often over worked.
125. Personnel are allowed to work on aircraft or equipment when "hung-over."
126. Personnel are not comfortable telling supervisors that they have personal problems.
127. NX works longer shifts than DX.
128. Personnel are assigned more than one task at a time making it difficult to concentrate on one job.

129. My maintenance officer/MCPO would understand if I did not feel comfortable working on an aircraft or equipment because I was having a family problem.
130. Publications are available, understandable, and used.
131. I am comfortable admitting to my supervisor that I have made a mistake.
132. Supervisors tolerate "short-cuts."
133. Most maintainers would rather cover up a mistake than admit to it.
134. Admitting to having an illness such as a cold is considered trying to "weasel out of work."
135. My work center is undermanned.
136. My division CPO is aware of my daily workload.
137. M/C would never put me in work on a job that could put me in an unsafe situation.
138. I am never rushed to complete a task.
139. Much of the pressure from M/C to complete a job is perceived and not real.
140. My supervisor is responsible for informing M/C if I feel they are pressuring/rushing me.
141. All known problems are addressed or corrected prior to an aircraft being released "safe for flight."
142. I am considered to be an important part of our maintenance department.
143. I feel comfortable reporting someone who I consider puts me in an unsafe situation.
144. Unprofessional behavior is not tolerated in the maintenance department.
145. Maintenance management encourages me to perform maintenance "by the book."
146. Disciplinary problems are not considered by maintenance management to affect a person's ability to perform his/her job.
147. If an unsafe condition existed, it would be recognized by M/C, Q/A, or the W/C supervisor before it became a problem.
148. All personnel in my department are physically capable of doing there jobs.
149. Intentional violations of proper procedures are dealt with swiftly.
150. QA is looking out for my safety.
151. I am briefed on al possible hazards associated with performing a job prior to starting that job.
152. QA is considered to be the technical experts.
153. QA is never pressured by maintenance leadership to sign off a gripe.
154. My job is as important as the aircrews.
155. My job (role) is considered to be important in achieving the overall command goal.

APPENDIX C. PROTOTYPE MCAS

Purpose: The purpose of this survey is to try and gain valuable insight into the maintenance community's perception concerning aviation mishaps within the Navy and Marine Corps. Your participation and answers will be used as a guide in the Navy's on-going efforts to lower the aviation mishap rate.

The first fifteen questions, part I, regard biographical data; information particular to yourself. This information will aid in the analysis of your responses. NO attempts will be made to identify individual respondents or their organizations.

Part II has 67 questions pertaining to the maintenance community. Please respond to the questions with the answer that most correctly reflects your honest opinion. Using a #2 pencil, completely darken each response.

Thank you in advance for your participation!

PLEASE RESPOND TO EACH ITEM.

1. Your rank? ( ) E-1 - E-3 ( )E-4 - E-6 ( )CPO E-7 + ( )Officer

2. Your community?

VFA	( )	HS	( )	VMFA	( )	VF	( )	HSL	( )
VMA	( )	HC	( )	VP	( )	HCS	( )	VX	( )
VR	( )	VQ	( )	VAQ	( )	VAW	( )		

3. Your designator? (LDO, 152X, etc)? __________ / NEC __________

4. Are you currently a department head? ( ) Yes ( ) No

5. Your service? ( ) USN ( ) USNR TAR ( ) SELRES ( ) Other

6. Your shift? ( ) DX ( ) NX ( ) MidX ( ) Other, specify_______

7. Total years of service? _________

8. Total years of Aviation Maintenance experience? ________

9. A-School graduate? ( ) Yes ( ) No ( ) N/A

10. Education level:( ) GED ( ) High School ( )College, # of years___

11. Unit home location? ( )East coast ( )West Coast ( )Other_________

12. Your rating? ( )AD/AM ( ) AE/AT ( )PR/AME ( )AO ( )Other _______

13. Your age? ( ) 17-20 ( ) 21-25 ( ) 25-30 ( ) 30+

14. Current maintenance qualifications?

    ( )Safe for Flight ( )QAR
    ( ) CDI ( )Supervisor
    ( )SPO ( )N /A

15. Duty: ( ) Shore ( ) Sea

Part II

1. My command adequately reviews and updates safety practices.	( )	( )	( )	( )	( )
2. The command has a dedicated program that targets individual training deficiencies.	( )	( )	( )	( )	( )
3. My command monitors maintainer qualifications.	( )	( )	( )	( )	( )
4. Support equipment licensing is monitored in this command.	( )	( )	( )	( )	( )
5. Tool Control is taken seriously at my command.	( )	( )	( )	( )	( )
6. My command recognizes individual safety achievement through rewards and incentives.	( )	( )	( )	( )	( )
7. Unprofessional behavior is not tolerated in the maintenance department.	( )	( )	( )	( )	( )
8. My command has a problem with passdown between shifts.	( )	( )	( )	( )	( )
9. My command follows established standards and maintains quality control.	( )	( )	( )	( )	( )
10. CDIs/QARs are sought after positions in my command.	( )	( )	( )	( )	( )
11. My command temporarily restricts maintainers who are having personal problems.	( )	( )	( )	( )	( )
12. Based upon my command's current manning and assets, it is over-committed.	( )	( )	( )	( )	( )
13. My command ensures all maintainers are responsible and accountable for safe maintenance.	( )	( )	( )	( )	( )
14. My command ensures the uniform enforcement of SOPs among unit maintenance personnel.	( )	( )	( )	( )	( )
15. Within my unit, good communication flow exists up and down the chain of command.	( )	( )	( )	( )	( )
16. Coordination is conducted between M/C , W/C and QA prior to incorporation of TDs.	( )	( )	( )	( )	( )
17. Inspectors perform all required actions before sign off.	( )	( )	( )	( )	( )
18. Supervisors encourage reporting safety concerns without fear of retribution.	( )	( )	( )	( )	( )

19. Supervisors discourage violations of SOPs, or NAMP guidelines.	( )	( )	( )	( )	( )
20. To meet operational commitments, supervisors allow "cutting corners".	( )	( )	( )	( )	( )
21. Supervisors manage the hazards associated with maintenance and flight line operations.	( )	( )	( )	( )	( )
22. Supervisors are more concerned with mission completion than aircraft maintenance.	( )	( )	( )	( )	( )
23. My division CPO is aware of individual daily workload requirements.	( )	( )	( )	( )	( )
24. Unsafe conditions are recognized and addressed by M/C, Q/A, or W/C supervisors.	( )	( )	( )	( )	( )
25. Supervisors communicate command safety goals, programs and procedures.	( )	( )	( )	( )	( )
26. Supervisors are actively involved in the safety program and management of safety matters.	( )	( )	( )	( )	( )
27. Supervisors set the example for compliance to established maintenance standards.	( )	( )	( )	( )	( )
28. Supervisors are responsive to unexpected changes and anticipate potential hazards.	( )	( )	( )	( )	( )
29. W/C supervisors are respected by the maintenance chief/officer.	( )	( )	( )	( )	( )
30. All maintenance evolutions are properly supervised by qualified personnel.	( )	( )	( )	( )	( )
31. Work center supervisors , division CPOs and M/C work well together.	( )	( )	( )	( )	( )
32. Aircraft moves are briefed and detailed personnel are qualified.	( )	( )	( )	( )	( )
33. Maintainers are briefed on potential hazards associated with maintenance activities.	( )	( )	( )	( )	( )
34. My supervisor shields me from outside pressures which may affect my work.	( )	( )	( )	( )	( )
35. QARs are never pressured by the maintenance supervisors to sign off a gripe.	( )	( )	( )	( )	( )
36. My MO/MCPO understand if I feel uncomfortable performing maintenance due to personal issues.	( )	( )	( )	( )	( )
37. Maintainer staffing is sufficient from shift to shift.	( )	( )	( )	( )	( )

38. Maintenance control is effective in managing all maintenance activities.	( )	( )	( )	( )	( )
39. Multiple job assignments and collateral duties adversely affect maintenance.	( )	( )	( )	( )	( )
40. Personnel turnover negatively affects my command's ability to operate safely.	( )	( )	( )	( )	( )
41. Violations of SOP, NAMP guidelines, or other procedures are common in my command.	( )	( )	( )	( )	( )
42. Proper tools and equipment are available, serviceable and used.	( )	( )	( )	( )	( )
43. Maintenance Control never troubleshoots aircraft discrepancies.	( )	( )	( )	( )	( )
44. Required publications are available, current, and used.	( )	( )	( )	( )	( )
45. Maintenance gripes are either corrected or addressed prior to flight.	( )	( )	( )	( )	( )
46. CDIs/QARs routinely monitor maintenance evolutions.	( )	( )	( )	( )	( )
47. My command has a reputation for quality maintenance.	( )	( )	( )	( )	( )
48. The QA division is respected in my command.	( )	( )	( )	( )	( )
49. Signing off PQS/JQRs/PARs is taken seriously and not gun decked.	( )	( )	( )	( )	( )
50. Maintenance quality on detachments is the same as that in homeport.	( )	( )	( )	( )	( )
51. Day and Night Check have equal workload and are equally stressful/fatiguing.	( )	( )	( )	( )	( )
52. QARs are viewed as helpful, and QA is not "feared" in my command.	( )	( )	( )	( )	( )
53. Peer influence discourages violations of SOP, NAMP guidelines or other procedures.	( )	( )	( )	( )	( )
54. Personnel are uncomfortable telling supervisors about personal problems including illness.	( )	( )	( )	( )	( )
55. I am provided adequate resources (time, personnel and equipment) to accomplish my job.	( )	( )	( )	( )	( )
56. In my command, we believe safety is an integral part of all maintenance and flight line operations.	( )	( )	( )	( )	( )

57. I feel I get all information (internal and external) required to perform my job safely.	( )	( )	( )	( )	( )
58. Individuals feel free to report safety violations, unsafe performance, or other unsafe behavior.	( )	( )	( )	( )	( )
59. My command uses safety staff to manage personnel at risk.	( )	( )	( )	( )	( )
60. Our command climate promotes safe maintenance and flight operations.	( )	( )	( )	( )	( )
61. Safety decisions are made at the proper command levels.	( )	( )	( )	( )	( )
62. Safety is part of maintenance planning, and additional training/support is provided as needed.	( )	( )	( )	( )	( )
63. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.	( )	( )	( )	( )	( )
64. Safety education and training in my command are comprehensive and effective.	( )	( )	( )	( )	( )
65. The safety department is respected by supervisors and maintainers.	( )	( )	( )	( )	( )
66. Maintenance Safety Petty Officer is a sought after billet in my command.	( )	( )	( )	( )	( )
67. The command uses medical staff to manage occupational hazards and personnel at risk.	( )	( )	( )	( )	( )

APPENDIX D. COMPONENT SURVEY DESCRIPTIVE RESULTS

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
1	108	4.45	0.702	93	4.45	0.634	67	4.39	0.758	268	4.44	0.692
2	108	3.86	0.942	93	3.90	0.835	67	3.72	1.070	268	3.84	0.940
3	107	4.44	0.881	92	4.29	0.749	66	4.27	0.755	265	4.35	0.849
4	106	4.39	0.952	92	4.36	0.764	67	4.24	0.836	265	4.34	0.936
5	106	4.54	0.864	93	4.86	0.406	67	4.61	0.673	266	4.67	0.803
46	105	4.24	1.020	90	4.18	0.680	65	4.20	0.775	260	4.21	0.960
59	104	3.92	1.050	90	3.91	0.802	67	3.73	1.109	261	3.87	1.088
67	105	3.30	1.050	91	3.49	1.004	66	3.08	1.154	262	3.31	1.119

MOSE Process Auditing Component

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
6	106	3.60	0.976	93	3.83	3.828	67	3.90	1.103	266	3.78	1.120
7	105	3.97	1.222	92	4.14	0.859	67	3.87	1.100	264	3.99	1.115
18	107	4.27	0.960	93	4.22	0.845	67	4.01	1.007	267	4.17	0.968
19	105	3.40	1.350	92	4.11	0.883	66	4.03	0.960	263	3.85	1.216
36	101	3.38	1.120	89	3.28	0.988	64	3.17	1.121	254	3.28	1.187
41	105	2.45	1.180	93	2.11	1.098	66	1.94	1.006	264	2.16	1.145
53	105	3.68	1.090	92	3.62	0.959	66	3.53	1.099	263	3.61	1.107
54	105	2.64	1.220	91	2.49	1.109	65	2.91	1.169	261	2.68	1.202
58	105	4.23	0.990	92	4.35	0.702	66	4.05	1.143	263	4.21	1.044
60	105	4.38	0.810	92	4.42	0.683	67	4.28	0.901	264	4.36	0.914

MOSE Reward System and Safety Culture Component

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
9	107	4.25	0.814	93	4.30	0.672	66	4.36	0.572	266	4.31	0.756
10	103	3.70	1.027	92	3.73	0.800	65	3.75	0.936	260	3.73	1.048
17	106	4.30	0.790	92	4.22	0.836	67	4.24	0.854	265	4.25	0.898
20	106	1.99	1.190	92	1.82	1.016	66	2.02	1.143	264	1.94	1.128
37	101	2.70	1.160	91	3.16	0.981	67	2.79	1.122	259	2.89	1.186
42	105	3.54	1.300	90	3.89	0.965	66	3.89	1.111	261	3.78	1.215
44	107	4.21	0.990	89	4.33	0.750	66	4.32	0.914	262	4.28	0.930
45	103	4.32	1.030	91	4.34	0.749	66	4.35	0.850	260	4.34	1.063
47	106	4.41	0.880	92	4.51	0.703	66	4.62	0.576	264	4.51	0.847
48	105	4.03	1.140	92	4.34	0.745	66	4.29	0.855	263	4.22	1.047
49	103	3.84	1.230	91	4.01	0.960	66	3.88	1.060	260	3.91	1.212
50	104	3.64	1.270	92	4.14	0.884	66	4.00	1.137	262	3.93	1.219

MOSE Quality Component

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
11	103	3.04	1.056	91	3.19	0.918	65	3.28	0.875	259	3.17	1.050
12	105	2.93	1.120	92	3.15	0.983	66	3.00	1.123	263	3.03	1.116
21	106	3.94	1.000	92	3.89	0.805	66	3.98	0.903	264	3.94	0.969
22	107	2.32	1.290	92	2.03	0.966	66	2.15	1.056	265	2.17	1.135
23	105	3.80	1.100	90	3.73	0.981	63	3.65	1.109	258	3.73	1.125
24	107	4.33	0.760	92	4.30	0.752	66	4.21	0.814	265	4.28	0.813
40	105	2.92	1.270	91	2.93	0.892	66	2.86	1.201	262	2.91	1.165
51	103	2.60	1.220	87	3.21	0.904	66	2.68	1.166	256	2.83	1.189
55	104	3.50	1.150	88	3.81	0.981	67	3.51	1.106	259	3.60	1.167
61	106	4.08	1.020	92	4.24	0.717	67	4.12	0.930	265	4.15	0.964
62	104	4.15	0.930	92	4.27	0.772	67	4.24	0.818	263	4.22	0.986
63	104	3.80	1.190	92	4.07	1.003	66	4.12	0.969	262	3.99	1.174

MOSE Risk Management Component

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Tot	Avg	SD	Tot	Avg	SD	Tot	Avg	SD	Tot	Avg	SD
13	106	4.35	0.829	92	4.33	0.730	67	4.28	0.692	265	4.32	0.843
14	106	3.98	0.976	92	4.03	0.870	66	4.12	0.775	264	4.04	0.954
25	106	4.08	0.950	92	4.12	0.782	66	3.98	0.920	264	4.06	0.951
26	106	3.98	1.000	92	4.18	0.662	66	4.05	0.919	264	4.07	0.939
27	107	3.95	0.960	91	4.14	0.754	66	3.97	0.911	264	4.02	0.913
28	106	3.97	0.950	92	4.01	0.791	66	3.88	0.851	264	3.95	0.933
29	107	3.79	1.070	91	3.45	1.213	66	3.83	1.090	264	3.69	1.155
30	106	3.85	1.090	92	4.15	0.725	66	4.08	0.966	264	4.03	1.011
38	105	3.92	1.090	93	3.82	0.988	66	3.77	1.049	264	3.84	1.114
39	104	3.30	1.200	92	3.10	0.973	66	3.36	1.159	262	3.25	1.175
56	106	4.49	0.810	92	4.57	0.599	67	4.61	0.602	265	4.56	0.792
64	105	4.07	0.960	92	4.10	0.757	67	4.12	0.879	264	4.09	0.968
65	104	3.92	1.100	92	4.07	0.823	67	4.01	1.037	263	4.00	1.100
66	102	3.03	1.100	90	3.21	0.966	67	3.10	1.032	259	3.12	1.126

MOSE Command and Control Component

Question	Fleet Support Squadron			Patrol Squadron			Combat Support Squadron			Combined Squadrons		
	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev	Total	Avg	StdDev
8	102	2.78	0.953	92	2.38	1.137	67	2.49	1.146	261	2.55	1.237
15	107	3.75	1.222	93	3.51	1.039	67	3.22	1.152	267	3.49	1.175
16	103	3.88	0.953	91	3.65	0.970	67	3.73	0.827	261	3.75	1.055
31	106	3.78	1.100	92	3.60	1.070	66	3.61	1.149	264	3.66	1.141
32	105	4.00	1.050	92	4.40	0.696	66	3.91	1.092	263	4.10	1.060
33	104	3.91	0.980	91	4.07	0.892	65	4.00	0.952	260	3.99	1.053
34	103	2.91	1.010	87	3.21	1.013	64	2.91	1.019	254	3.01	1.092
35	103	3.66	1.230	91	3.53	1.036	66	3.45	1.126	260	3.55	1.228
43	103	2.70	1.210	90	2.41	1.189	66	2.61	1.175	259	2.57	1.236
52	106	3.89	1.080	90	4.08	0.768	66	3.94	0.943	262	3.97	1.006
57	105	3.96	1.050	91	4.13	0.748	67	4.12	1.023	263	4.07	1.035

MOSE Communication / Relationship Component

APPENDIX E. SUGGESTED QUESTIONS MODIFICATIONS

9. My command adequately reviews and updates safety practices.
1. My command follows established standards and maintains quality control.
13. My command ensures all maintainers are responsible and accountable for safe maintenance.

New question: My command adequately reviews and updates safety practices, follows established standards and maintains quality control, while ensuring that all maintainers are responsible and accountable for safe maintenance.

3. My command monitors maintainer qualifications.
4. Support equipment licensing is monitored in this command.

New question: My command monitors maintainer qualifications and support equipment licensing.

57. I feel I get all information (internal and external) required to perform my job safely.
58. Individuals feel free to report safety violations, unsafe performance, or other unsafe behavior.

New question: I feel I get all information required to perform my job safely, and feel free to report safety violations, unsafe performance or other unsafe behavior.

30. All maintenance evolutions are properly supervised by qualified personnel.
33. Maintainers are briefed on potential hazards associated with maintenance activitites

New Question: Qualified personnel properly supervise all maintenance evolutions and maintainers are briefed on the potential hazards associated with maintenance activities.

42. Proper tools and equipment are available, serviceable and used.
55. I am provided adequate resources (time, personnel, and equipment) to accomplish my job.

New question: Proper tools and equipment are available, serviceable and used an I am provided adequate resources (time, personnel) to accomplish my job.

49. Signing off PQS/JQRs/PARs is taken seriously and not gun decked.
50. Maintenance quality on detachments is the same as that in homeport.

New Question: Signing off PQS/JQRs/PARs is taken seriously, not gun decked and maintenance quality is as high on detachments as it is in homeport.

2. The command has a dedicated program that targets individual training deficiencies.
14. My command ensures the uniform enforcement of SOPs among maintenance personnel.

New question: My command has a dedicated program that targets individual training deficiencies and ensures the uniform enforcement of SOPs among maintenance personnel.

37. Maintainer staffing is sufficient from shift to shift.
51. Day and night check have equal workload and are equally stressful / fatiguing.

New question: Maintainer staffing is sufficient, is equally worked and is equally stressed / fatigued from shift to shift.

16. Coordination is conducted between M/C, W/C, and QA prior to incorporation of TDs.
38. Maintenance control is effective in managing all maintenance activities.

New question: Maintenance control is effective in managing all maintenance activities, coordinating between M/C, W/C, and QA prior to the incorporations of TDs.

20. To meet operational commitments, supervisors allow cutting corners.
22. Supervisors are more concerned with mission completion than aircraft maintenance.

New question: Supervisors are more concerned with proper aircraft maintenance than mission completion and do not allow cutting corners to meet operational commitments.

64 Safety education and training in my command are comprehensive and effective.
65. The safety department is respected by supervisors and maintainers.

New question: Safety education and training in my command are comprehensive and effective and the safety department is respected by the supervisors and maintainers.

52. QARs are viewed as helpful, and QA is not "feared" in my command.
56. In my command, we believe safety is an integral part of all maintenance and flight line operations.

New question: Safety is an integral part of this command's maintenance planning/flight line operations, where QARs are helpful and the QA division is not "feared".

19. Supervisors discourage violations of SOPs, or NAMP guidelines.
53. Peer influence discourages violations of SOP, NAMP guidelines or other procedures.

New question: Violations of SOP, NAMP guidelines or other procedures are discouraged in this command.

5. Tool control is taken seriously in my command.
47. My command has a reputation for quality maintenance.

New question: My command has a reputation for quality maintenance and tool control is taken seriously.

18. Supervisors encourage reporting safety concerns without fear of retribution.
21. Supervisors manage the hazards associated with maintenance and flight line operations.
24. Unsafe conditions are recognized and addressed by M/C, Q/A, or W/C supervisors.

New question: Safety concerns or unsafe hazards associated with maintenance and flight line operations can be reported without a fear of retribution knowing that the W/C, Q/A, or M/C supervisors will address and manage them for proper corrections.

11. My command temporarily restricts maintainers who are having personal problems.
36. My MO/MCPO understand if I feel uncomfortable performing maintenance due to personal issues
67. The command uses medical staff to manage occupational hazards and personnel at risk.

New question: Medical staff is used to help identify, manage, and temporarily restrict personnel with personal issues and those who pose a risk to safe maintenance in this command.

10. CDIs and QARs are sought after positions in my command.
66. Maintenance Safety Petty Officer is a sought after billet in my command.

New question: QARs/ CDIs and Maintenance Safety Petty Officer are sought after billets in my command.

45. Maintenance gripes are either corrected or addressed prior to flight.
46. CDIs/QARs routinely monitor maintenance evolutions.
48. The QA division is respected in my command.

New question: The QA division is respected and CDIs / QARs routinely monitor maintenance evolutions ensuring that maintenance gripes are either corrected or addressed prior to flight.

Question 8:

Current: My command has a problem with passdown between shifts.
New question: My command does not have a problem with passdown between shifts.

Question 12:

Current: Based upon my command's current manning and assets, it is over-committed.
New question: Based upon my command's current manning and assets, it is not over-committed.

Question 20

Current: To meet operational commitments, supervisors allow "cutting corners."
New question: Supervisors do not allow "cutting corners" to meet operational commitments.

Question 22

Current: Supervisors are more concerned with mission completion than aircraft maintenance.
New question: Supervisors are more concerned with proper aircraft maintenance than mission completion.

Question 39

Current: Multiple job assignments and collateral duties adversely affect maintenance.
New question: Multiple job assignments and collateral duties do not adversely affect maintenance.

Question 40

Current: Personnel turnover negatively affects my command's ability to operate safely.
New question: Personnel turnover does not affect my command's ability to operate safely.

Question 41

Current: Violations of SOP, NAMP guidelines, or procedures are common in my command.
New question: Violations of SOP, NAMP guidelines, or procedures are not common in my command.

Question 54

Current: Personnel are uncomfortable telling supervisors about personal problems including illness.

New question: Personnel are comfortable telling supervisors about personal problems including illness.

APPENDIX F. FINALIZED MCAS

Purpose: The purpose of this survey is to try and gain valuable insight into the maintenance community's perception concerning aviation mishaps within the Navy and Marine Corps. Your participation and answers will be used as a guide in the Navy's on-going efforts to lower the aviation mishap rate.

The first fifteen questions, part I, regard biographical data; information particular to yourself. This information will aid in the analysis of your responses. NO attempts will be made to identify individual respondents or their organizations.

Part II has 35 questions pertaining to the maintenance community. Please respond to the questions with the answer that most correctly reflects your honest opinion. Using a #2 pencil, completely darken each response.

Thank you in advance for your participation!

PLEASE RESPOND TO EACH ITEM.

1. Your rank? ( ) E-1 - E-3 ( )E-4 - E-6 ( )CPO E-7 + ( )Officer

2. Your community?

VFA ( )	HS ( )	VMFA ( )	VF ( )	HSL( )
VMA ( )	HC ( )	VP ( )	HCS ( )	VX ( )
VR ( )	VQ ( )	VAQ ( )	VAW ( )	

3. Your designator? (LDO, 152X, etc)? ____________ / NEC __________

4. Are you currently a department head? ( ) Yes ( ) No

5. Your service? ( ) USN ( ) USNR TAR ( ) SELRES ( ) Other

6. Your shift? ( ) DX ( ) NX ( ) MidX ( ) Other________

7. Total years of service? __________

8. Total years of Aviation Maintenance experience? _________

9. A-School graduate? ( ) Yes ( ) No ( ) N/A

11. Education level:( ) GED ( ) High School ( )College, #yrs___
12. Unit home location? ( )East coast ( )West Coast ( )Other

12. Your rating? ( )AD/AM ( ) AE/AT ( )PR/AME ( )AO ( )Other

13. Your age? ( ) 17-20 ( ) 21-25 ( ) 25-30 ( ) 30+
14. Current maintenance qualifications?
( )Safe for Flight ( )QAR
( ) CDI ( )Supervisor
( )SPO ( )N /A

15. Duty: ( ) Shore ( ) Sea

Part II

1. My command has a dedicated program that targets individual training deficiencies and ensures the uniform enforcement of SOPs among maintenance personnel.	( )	( )	( )	( )	( )
2. My command monitors maintainer qualifications and support equipment licensing.	( )	( )	( )	( )	( )
3. My command has a reputation for quality maintenance and tool control is taken seriously.	( )	( )	( )	( )	( )
4. Unprofessional behavior is not tolerated in the maintenance department.	( )	( )	( )	( )	( )
5. My command has a problem with passdown between shifts.	( )	( )	( )	( )	( )
6. My command adequately reviews and updates safety practices, follows established standards and maintains quality control, ensuring that all maintainers are responsible and accountable for safe maintenance.	( )	( )	( )	( )	( )
7. QARs/ CDIs and Maintenance Safety Petty Officer are sought after billets in my command.	( )	( )	( )	( )	( )
8 . Medical and safety staff are used to help identify, manage, and temporarily restrict personnel with personal issues and those who pose a risk to safe maintenance in this command.	( )	( )	( )	( )	( )
9. Based upon my command's current manning and assets, it is not over-committed.	( )	( )	( )	( )	( )
10. Within my unit, good communication flow exists up and down the chain of command.	( )	( )	( )	( )	( )
11. Maintenance control is effective in managing all maintenance activities, coordinating between M/C, W/C, and QA prior to the incorporations of TDs.	( )	( )	( )	( )	( )
12. Inspectors perform all required actions before sign off.	( )	( )	( )	( )	( )
13. Safety concerns or unsafe hazards associated with maintenance/flight line operations can be reported without fear of retribution knowing that the W/C, Q/A, or M/C supervisors will address and manage them for proper corrections.	( )	( )	( )	( )	( )
14. Violations of SOP, NAMP guidelines or other procedures are discouraged in this command.	( )	( )	( )	( )	( )

15. Supervisors are more concerned with proper aircraft maintenance than mission completion and do not allow cutting corners to meet operational commitments.	( )	( )	( )	( )	( )
16. My supervisors are aware of individual daily workload requirements and recognize safety achievements through rewards and incentives.	( )	( )	( )	( )	( )
17. Supervisors communicate command safety goals, programs and procedures.	( )	( )	( )	( )	( )
18. W/C supervisors are respected by the maintenance chief/officer.	( )	( )	( )	( )	( )
19. Qualified personnel properly supervise all maintenance evolutions and maintainers are briefed on the potential hazards associated with maintenance activities.	( )	( )	( )	( )	( )
20. My supervisor shields me from outside pressures which may affect my work.	( )	( )	( )	( )	( )
21. QARs are never pressured by the maintenance supervisors to sign off a gripe.	( )	( )	( )	( )	( )
22. Maintainer staffing is sufficient, is equally worked and is equally stressed / fatigued from shift to shift.	( )	( )	( )	( )	( )
23. Multiple job assignments and collateral duties do not adversely affect maintenance.	( )	( )	( )	( )	( )
24. Personnel turnover does not affect my command's ability to operate safely.	( )	( )	( )	( )	( )
25. Violations of SOP, NAMP guidelines, or other procedures are not common in my command.	( )	( )	( )	( )	( )
26. Proper tools and equipment are available, serviceable and used and I am provided adequate resources (time, personnel) to accomplish my job.	( )	( )	( )	( )	( )
27. Maintenance Control never troubleshoots aircraft discrepancies.	( )	( )	( )	( )	( )
28. Required publications are available, current, and used.	( )	( )	( )	( )	( )
29. The QA division is respected and CDIs / QARs routinely monitor maintenance evolutions ensuring that maintenance gripes are either corrected or addressed prior to flight.	( )	( )	( )	( )	( )
30. Signing off PQS/JQRs/PARs is taken seriously, not gun decked and maintenance quality is as high on detachments as it is in homeport.	( )	( )	( )	( )	( )

31. Safety is an integral part of this command's maintenance planning/flight line operations, where QARs are helpful and the QA division is not "feared".	( )	( )	( )	( )	( )
32. Personnel are comfortable telling supervisors about personal problems including illness.	( )	( )	( )	( )	( )
33. I feel I get all information (internal and external) required to perform my job safely, and feel free to report safety violations, unsafe performance or other unsafe behavior.	( )	( )	( )	( )	( )
34. Maintainers are never purposely put in an unsafe situation to meet the flight schedule.	( )	( )	( )	( )	( )
35 Safety education and training in my command are comprehensive and effective and the safety department is respected by the supervisors and maintainers.	( )	( )	( )	( )	( )

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